A COURSE OF LECTURES

ON THE

GROWTH AND MEANS OF TRAINING

THE

MENTAL FACULTY.

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MENTAL FACULTY

DELIVERED IN THE UNIVERSITY OF CAMBRIDGE

BY

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PREFACE.

THE following Lectures were delivered in the University of Cambridge in 1888–89. When asked by the Teachers' Training Syndicate to give a course of lectures on the scientific observation and study of pupils in school, I gladly availed myself of this opportunity of putting forward those methods of making exact observations, and giving accurate descriptions of children which I have formulated after some years of careful study. A body of physical signs suitable for observation under the proposed conditions is here presented to the student.

It appears to me that the best way of imparting such knowledge is by carrying on the student-teacher from his studies in Physiology and Natural History, to the observation of children by similar scientific methods. The first chapter of this work is accordingly devoted to the study of natural objects in the same way as I would have you examine a child. The catalogue placed at the end of the volume gives further illustration on this subject.

Educational work presents so many practical difficulties that it is well to see what help we can get from the study of Nature, and the physical forces which control growth in all living things. A general knowledge of Natural History, Biology and Physics, is now so widely diffused as to render it possible to make these branches of science the basis for studying children as seen by us.

It is thought by many that the time has come when it is advisable that School Teachers, and others concerned in education, should acquire a more accurate and scientific knowledge of children of different kinds, and of pupils under different conditions—it may then be advisable that some systematic instruction on this subject should be provided, and included as a part of the pupil-teacher's curriculum and examination. A short course of instruction of this kind would render previous studies in science, psychology and school-management more practical, applying the whole to the daily routine of the duties of the school-room. The materials upon which the teacher works are the child's brain and body, whatever method he may use, and it seems likely that a general and continuous observation of the facts seen in pupils may help to remove some of the present defects in educational arrangements.

The doctor, in busy practice, finds each year a certain number of cases of "consumption" in his district, he would not know whether this disease were more or less prevalent in his locality than in the country at large, if means had not been taken to ascertain the general average of this condition, and its distribution among the population. A school may contain a considerable number of

"nervous children," this fact may be attributed by some to the management of the school, but at present we do not know the average of this condition and its distribution among the school population. This kind of knowledge would be very useful, and would help to settle some educational problems; some defective conditions are frequently charged as produced by education which may be due to other causes.

It would greatly aid our knowledge of the school population, and the solution of problems dependent thereon, if an examination of, say 50,000 pupils in various selected schools, were made and a report issued.

The ideal of perfect mental function, which should be constantly before the teacher's mind, is only to be known by observation and study. The student-teacher needs training in quick perception, visual and auditory, and in ready description of conditions seen in children. In visiting schools it is not difficult to recognise the apt and able teacher by his ready and accurate account of the children in his class. To gain this special aptitude is one reason for urging these studies, when once the faculty of observing and describing has been acquired by teachers they have a power in their hands of the highest professional value, and may accumulate an experience that will assure success in management and skill in training their pupils.

Teaching has become a highly honoured and very important profession.

When we consider that about one sixth of the population is under school training, and that more than 6,000,000 pupils are under the daily influence of school teachers, we see at once their enormous power and the

deep interest we all have in teaching as a profession. It may well be doubted whether any other profession or calling in life produces so large an influence by its daily work.

The responsibilities of educating the children of a nation are immense, all branches of science, and our own profession in particular, may well be called upon to take their part. In the following pages it will be my endeavour to try and advance a method of physico-psychology, and show how we may found a section of state medicine taking cognizance of all questions concerning the conditions of pupils in school, their surroundings, and the physical outcome of school training.

Classification of pupils is important to your results. Learn to know the make of your pupils that you may know their tendencies in action, and the effects of your training. Further knowledge of children will aid your methods, and enable you to assess results with allowance for the material you work upon. Some have objected to any knowledge of methods of observation of children being placed before teachers—'a little knowledge is a dangerous thing'—but surely the head-master or mistress can control this as well as the tendency to exceed the part assigned to under teachers in other matters.

Remember that to be successful in training and teaching you must be strong, and that it is knowledge that gives power, the knowledge not only of scholastic matters, but a wide and deep knowledge of children in their bodily and mental character.

It is obvious that in presenting new work it is impossible to avoid some technical terms, but these are

fully explained in the text; an index is provided which enables the reader to make such cross references as may be necessary.

I gladly acknowledge my obligations to Dr J. A. Coutts for his kind assistance in preparing certain formulae, and in correction of portions of the text.

F. W.

5, PRINCE OF WALES TERRACE,
KENSINGTON PALACE, W.

*** A chronological list of the author's lectures and scientific papers on the subject of this work is given at pages 213—215.

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CHAPTER I.

NATURE'S METHODS; THE CHILD A PART OF NATURE'S WORK.

THE child we submit to educational processes is a living being, a part of Nature's work, and to understand him thoroughly we must study the child in conjunction with what is known of other living beings.

Purpose of education.

The object of education and training is to bring the child into harmony with his surroundings, the home and the school, in order that in future years he may live harmoniously with whatever circumstances may surround him: we want early to impress him in such a way that in the future his strength, development and character may be manly.

The child compared with other living things.

A child is, no doubt, very different from the young of all lower living beings, but in many points there is a uniformity in the methods of nature, and in the methods of describing action in all living things. We shall commence by glancing at methods of growth and vital action in the lower groups of organic beings; in these comparatively simple structures we shall study the methods, or as they are often called "Laws of Nature", and subsequently apply such knowledge to the study of children, as regards growth, development and mental functions. Further, if we want to train the child into a condition of harmony with Nature, we must know all we

Laws of Nature.

Nature's work. can of that universal work of Nature of which the child is a part that we may aid Nature's work and never thwart it. It is not here intended to discuss man's place in Nature, but we must study man among Nature's works.

The body. The body of man is a living thing, one among many living things, influenced and nourished by supplies of food, and stimulated by such forces as heat, light, sound, touch, &c. One general plan seems to run through the whole series, and certain laws or generalisations appear to apply to all alike, though in different degrees.

Our present concern in glancing at the circles of organic life, is to gain any knowledge possibly bearing upon our understanding of growth, action and mental function, or, as we may say, the processes of nutrition in the bodies and brains of children.

A proposition as to living things. Let me state a proposition which I have dwelt upon largely elsewhere, one that appears to me of primary importance in the scientific study of methods of cultivating the powers of children. "All vital phenomena must take place in a living body, and their occurrence implies not only nutritive supply, but also stimulation by forces from without."

Cause and effect. To speak of a child as a part of Nature's work is to make analogies between him and other living things: in making such analogies the greatest care must always be taken as regards definition, and logical inferences. To be strictly accurate it is necessary to define what we compare, and to state the characters between which comparisons are to be made. It is very common to speak of cause and effect, but it seems to me that in the complex problems that will come under our notice, it will be better to simply note the antecedents of our

facts rather than to speak of them necessarily as causes. At some points in our work we shall have to dwell on certain methods of observation, thought, argument and logic. Looking steadily at the works of Nature, compelling ourselves to see what is before us, trying to distinguish what we see from what we infer—such is good practice for the mental powers. In Lecture III. we shall try to describe the methods of brain action, as they produce the expression of Mind. If you will follow my methods of describing some simple growing things, it will be easier for me to explain the more complex phenomena taking place among brain cells. *Nature our guide.*

If a pea seed be placed on damp moss and kept in the dark at a sufficient temperature, the access of air being free, it soon begins to sprout. The seed swells, growth commences, and protrusion of the radicle follows. Later on, the covering of the seed splits and the embryo stem rises into the air, bearing a delicate tuft of leaves. It has been shewn by Sachs, and by Charles Darwin, that all parts of the plant move constantly, thus constantly binding both the root and the apex of the stem in more or less circular tracts. This spontaneous movement is called circumnutation. The movements of the apex of a growing stem were carefully traced by Charles Darwin; the apex moved in a more or less elliptical curve, with many zigzags. This movement results from the unequal state of congestion of the vegetable cells, the side of the stem on which for the time the turgescence is greater being temporarily the convex side, and it has been shewn that this turgescence may be followed by permanent growth. Darwin, in his researches, has shewn that apparently every growing part of every plant is continually circumnutating, though often on a small scale. "Even the stems of seedlings, *A growing seed, its movements.*

Spontaneous movement. before they have broken through the ground, as well as their buried radicles, circumnutate, as far as the pressure of the surrounding earth permits. In this universally present movement, we have the basis, or ground work for the acquirement, according to the requirements of the plant, of the most diversified movements." Thus the movements of the stems of twining plants, and the tendrils of climbers, result from a mere increase of the amplitude of the ordinary movements of circumnutation. The movements of the so-called sleep of plants, the movements of various organs towards the light, are all modified forms of circumnutation. Thus there are always movements in progress, and external stimuli largely control their amplitude and direction.

Young plants move much. In the growth of plants, especially while they are young, it is the rule for, first one side, and then another of a member, to grow more rapidly than the rest, curvatures being thus caused, the convexity of which always indicates the side that is at the time growing most rapidly. If another side then grows more rapidly, it becomes convex, and the curvature changes its direction. These curvatures are caused by the unequal growth of different sides of an organ, and have been called by Sachs "Nutations." These nutations occur most evidently when growth is very rapid. Very common is it to find the apex of the erect stems above the curved growing part, to move round in a circle or ellipse, the region of most active growth moving gradually; this Sachs terms "revolving nutation." As regards the stem of a plant which happens to be bent towards the north, it will gradually bend more and more towards the east till it faces the east, then towards the south.

When, in place of looking at the results of the movement of the apex of the radicle of the pea plant, as

traced upon paper, we come to look at the minute changes in the mechanism which produces the movement, we find it necessary to subdivide the thing observed, the radicle, into the parts which can swell or grow as individuals, i.e. the cells of which it is composed, and we look at action in separate groups of cells arranged round the circumference of the stem. *Parts of the object observed.*

The ascending axis of the seedling is seen to be bent a little below the apex, and the arched neck, with the tender tuft of leaves pointing downwards, is pushed upwards by growth of the stem. This arched condition, the result of growth, is due to unequal elongation of the two sides of the stem, that which grows the quickest becoming convex as a mechanical result. One word describes the arching of the stem, but when we seek the cause thereof we must observe separately the two halves of the stem, and we find that action is unequal in the parts, and the arching is a mechanical result thereof. *Quantity of growth in each part.*

Look at the seedling which has been grown in darkness, and compare its parts with those of a plant grown with due light. That grown in darkness has a long stem and small leaves: this shews that light can control the quantities of growth. A plant grown near a window so that one side of it is more illuminated than the other is seen to have the stem bent concavely towards the light, this is due to the action of light in checking growth on one side more than on the other. *Seedling in darkness.*

We see that the separate portions of the seedling plant may act and grow independently of one another, and that such mode of growth may result in movement. Light acting upon the circumnutating stem alters the ratios of action in the vegetable cells. Light controls the quantities of action in certain cells, and definite *Action of light.*

Spontaneity controlled by physical forces.

movement of the plant results. The plant does not move of itself, but the light regulates its spontaneous movements so that bending in the direction with the stem results. When the plant is quietly growing, circumnutating as it ascends, it is all ready for the special action which follows when light illuminates one side more than the other. The plant is active, its activity causes the movement, and this spontaneous movement may be controlled to something like an intelligent action; but while the plant is steadily bending towards the light there is very little spontaneous movement.

Parts of a living thing that grow separately.

Continuing our study of Nature's methods as seen in the growth of plants—look at a potato, a radish, a turnip or a carrot. A potato may be called a living thing, like the seed, it is capable of growth when placed in moist ground at a sufficient temperature. The botanists call the potato a tuber because it has been shewn that it is a much thickened underground stem or branch, the so-called 'eyes' of the potato being buds which can develope stems. Look at the potato which has begun to grow, and see that it is not *one* living thing, but has many points of growth, many parts that can act separately. If kept dry it will not sprout, it needs moisture and warmth to make it grow, these conditions must act upon it before it can grow. The material from which the early growth takes place is the starch so abundantly stored up in the potato, its early food is self-contained! Now look at a radish, turnip or carrot; these are roots, they have no buds, they do not possess many parts like the eyes of the potato which can act separately. In this respect the turnip is less complicated, lower, less like an intelligent thing than a potato!

Looking at the carrot let me compare a wild and a cultivated specimen. The wild carrot differs from the

cultivated variety in the size and weight of the root. If we make a transverse section of the root, we see that the ratio of cellular material to the fibrous is different in the two varieties, the cellular tissues being more abundant in the cultivated variety.

Double action. Double action, or two outcomes of action, often occur simultaneously in a living thing. In the potato plant growing under favourable circumstances, a double action occurs, assimilation or manufacture of starch being one, and storage in the tubers underground the other. In the germinating pea unequal bilateral growth leads both to curvature and bending of the plumule downwards. A pulvinus is the motor organ at the base of certain leaves, if it be touched, not only do its cells swell on one side but movement of the leaf results, no further structural changes occur.

In a leaf of *Drosera rotundifolia*, if an insect settles on one tentacle, a stimulus is transmitted to the others, causing them both to secrete, and then bend towards the fly. Here the stimulus is transmitted to a distance and then produces a double action.

Proportions of growth. A head of young convolvulus shews us other points worthy of special observation and description among growing things. Compare the young leaves with the old ones, those near the apex with those lower down: it will strike you at once that as growth proceeds the form of the leaf alters, it becomes broader in comparison to its length, the ratio of length and breadth changes as growth proceeds. This last is very commonly seen in many plants as growth continues. The ratios or proportions of growth are always very important. It is the proportions of growth in the different parts of the stem of the convolvulus that cause its head to revolve and climb. Other specimens may be put forward shewing

proportional growth, or ratios of action, and results thereof.

Chestnut buds. The buds of the horse chestnut shew us some results of ratios in development of parts, or proportional growth. During the winter months the inner parts of the bud are enclosed by bud-scales, or modified leaves without stalks. As these scales grow, the cells on the outer surface increase more quickly than those on the inner side, and as a mechanical result these scales become more concave towards the centre of the bud and envelope it, thus affording protection from the weather and attacks by insects. The young imperfect leaves are closely packed within, and these also grow quickly on the outer side, causing them to press towards the centre of the bud. When spring time comes, with increased temperature comes increased nutrition, then changes occur in the ratios of growth. The inner surfaces of both bud-scales and young leaves grow at a greater rate than the outer surfaces and thus the curvatures are altered. The inner surfaces become convex and the bud opens. Growth in the scales now almost ceases, while the quantity of growth in the axis of the bud and the leaves is augmented as they become exposed to the action of light, heat and the atmosphere.

Time of growth. The time of growth and the results following from it may be illustrated by specimens. Here is a head of sun flower; it is a colony of florets collected on one support. The little flowers at the outer edge are of a different shape from those in the centre. A floret from the margin has a tubular corolla greatly prolonged on one side in strap-like form, hanging over the margin of the flower head. The florets of the centre are tubular and cup-shaped, and of equal height all round. These are points concerning the arrangement of the florets worthy of special notice;

the florets in the circle at the margin open first and attract the visits of insects, the next day a circle nearer the centre opens, and so on in succession; thus fresh flowers open each day. We will now look at a single floret in detail, specially noticing the arrangement with regard to the relative growth of the stamens and the pistil, which results in cross-fertilization of the flowers. The stamens are united by the margins of their anthers forming a tube into which the pollen is discharged. The stamens grow to their full height and maturity before the pistil, which during the early stage of the flower is short and immature. When the anthers are ripe and have filled their tube with pollen, the style begins to grow, and passes up the tube formed by the anthers, pushing the pollen powder before it which now accumulates in a heap at the top of the flower. Later, the continued growth of the style places the stigma as the most prominent part of the flower, its lobes open and expose the receptive surface. An insect visiting the flower in its early condition meets with a heap of pollen-dust at the top of each floret, and thus dusts its abdominal surface. When the insect later on visits a flower in the later stage of growth, with the style protruded and expanded, it deposits some pollen from the former flower upon the prominent and receptive stigma. Thus cross-fertilization is effected. The time of each act described is an essential attribute of the process which brings about cross-fertilization or conveyance of pollen from one flower to another. In the Fuchsia, Campion and Epilobium, we see examples where the relative times of protrusion of the anthers and style lead to cross-fertilization, the anthers first protruding, the stigmas maturing later.

Sunflower.

The time of action produces the effect.

The specimens we have examined shew the importance of looking to all the parts of any living thing which

can grow or act separately, and the importance of observing the relative time and quantity of action in each part. We now want to determine some of the forces or causes which may regulate the time and quantity of action in the parts of living things. I must crave your indulgence if I here assume an hypothesis which I have endeavoured to illustrate and support by evidence given elsewhere. Vital acts only must be observable in living things which must be supplied with pabulum or food material and also stimulated by some force. The forces which thus stimulate acts of nutrition, appear also to determine and control the time and the quantity of action. In the work referred to, numerous examples are classified, where nutrition of parts of living things is controlled by such forces as light, heat, sound, pressure, gravity, &c. Time, however, prevents me repeating my evidence here.

Vital action means food and stimulus.

Limit of power.

We have considered thus far what to observe in looking at Nature's work in living things, and I have referred to my hypothesis as to the mode in which physical force controls vital acts. There is however, obviously, a limit to the capacity of every living thing for the performance of its functions. In seeking to observe these limits, we must first determine the outcome of its action, and how it is to be observed. In each living thing there is an intrinsic tendency to continue its growth for a certain period, and up to a certain amount; this appears to be due to inherited antecedent impressions, but the tendency may be altered in succeeding generations. Cultivation and training may increase capacity for action in an individual, as well as in a species. Cultivation of the apple tree in successive generations has improved the capacity for producing large fruit; cultivation of the carrot gives us large roots in comparison to the small ones found in the wild species.

Cultivation increases capacity.

Feeding. As regards the individual, the capacity for action may be determined by feeding, or by the conditions of stimulation. A sensitive plant, if well fed, becomes very slightly sensitive to a blow, and will not move its leaflets; an animal deprived of food soon loses its motor power. The intellectual capacity of children may be increased by feeding when the previous diet has been deficient (see Report of Birmingham Committee). Over-feeding is equally undesirable, especially just before lessons. By the proper employment of exercise for every organ and part of the body, we may increase capacity for action by stimulating to the full the nutrition of each part.

Feeding and stimulating. There is a limit to the capacity for function in every living thing, but if the food supply is sufficient, the quantity of nutrition is directly proportional to the amount of stimulation, up to a certain amount. When growth in a child is deficient from want of food, feeding may be a most potent factor in augmenting the capacity for action. When feeding has been sufficient and stimulation or exercise defective, the course of management is obvious. There are cases of defective nutrition of the body where high feeding is very necessary, especially among some nervous children.

When I say that the capacity for action may be increased or diminished by stimulation, I mean by such physical conditions as pressure, touch, light, the sight of objects, or sound (see Catalogue). Diminished stimulation of a muscle leads, not only to less work done, but also to wasting of its substance; it is not sufficient for nutrition and good work of the muscle that it be supplied with blood, it must also be stimulated and exercised. Probably there is much less limitation to the growth of a crystal than of a living thing.

Increasing capacity. We may try to cause variation in the limit of capacity for action, and probably it is easier to increase the quantity of action than its duration. There is a more distinct limit to the duration of life than to the quantity of action that shall occur during the period of life. The leaf of a tree has its own period for duration of life, apart from *Limited duration of a leaf.* the effects of late springs and early autumns. The leaves of many trees separate (Gray, p. 87) from the stem, and fall by means of an articulation at the junction with the stem, which begins to form early in the season and is completed at the close. There is a kind of disintegration of a transverse layer of cells, which cuts off the petiole by a regular line, and leaves a clean scar. Intrinsic causes, acting in the plant, probably due to impressions made upon the ancestors by their surroundings, determine the duration of life of the leaf. In each living thing there is a tendency to grow for a certain period, and up to a certain amount.

In the infant, before birth, conditions of development occur which cannot proceed after birth, e.g. closure of certain openings and fissures. An ovule of the flower is a cellular body, it has but a small capacity for growth, and this lasts but a short time, unless it be fertilized or stimulated by the advent of a pollen grain. Fertilization stimulates the ovule and increases the capacity for nutrition and growth so that under favourable circumstances it developes into a seed. These two last are examples of altered capacity for growth.

Nature guides thinking. The study of Nature may guide us in all things, in observing and in thinking: in such work we must constantly make analogies and generalisations. Certain generalisations as to what to observe, and how to describe what we see, have been stated in pursuing our studies of plant life; how can we apply them to the

study of children? This will be shewn presently. We have seen the importance of the separate action of the different parts of the living thing observed, and their impressionability to control by forces around.

Analogy of a child and plant.

In applying any generalisations from the study of plant-life to the observation of children, we make analogies. We studied the germinating seeds, the turnip, the carrot and potato, the convolvulus and the ivy, and made some generalisations as to Nature's methods of action in living things. What does the potato shew us as to what to observe in a child's body or his brain? We find that it is necessary to observe the separate parts of the potato and the parts of the child that can move and act separately. We may place the potato and the child side by side, but what we compare in them is not the actual vital process in each but the time and the quantity of action in the parts of each; we find resemblance or analogy between the potato and the child in the fact that separate parts of each can grow and display action separately. In reality we do not compare the potato and the child directly, but the attributes of the nutritive processes in each, and we find that it is convenient to describe facts seen in the child, according to the methods used in describing the simpler organization of plants. A system of methodical procedure is thus put forward as a guide to the complex problems before us in our subsequent work. The studies of the astronomers were without fixed method and system till the minds of Kepler and Newton put forward definite modes of thought and observation (see Stewart's *Philosophy*).

A potato, its parts.

Aptness.

Aptness is a term given to a quality possessed by some living things, and indicates a condition of predisposition for action. A child who is ordinarily attentive and predisposed to study, may be said to be apt to learn,

Aptness in plants. or readily impressed by education. It will be well to illustrate aptness in the lower members of Nature's work. In the growth of the tissues of plants, chlorophyll grains play a very important part, decomposing carbonic acid gas under stimulation by light, thus supplying carbon to the plant. Professor Goodall (p. 287) says concerning this process:—"In regard to the genesis of the chlorophyll granules which are the essential constituents of the assimilative cells, the following view appears to be most in consonance with recent investigations. Imbedded in the protoplasm of every growing point there are peculiar bodies (plastids) which have substantially the same characters and structure as the protoplasm, and are more or less clearly differentiated from it even at an early period. As the cells, which develope from the growing point, assume the different characters which fit them for special service, for example, those in certain tubers and roots for store-houses, those in leaves for assimilation, and those in some flowers and fruits for colour, their plastids may likewise assume special characters. Those which are destined for the store-houses become leuco-plastids, or starch-formers; those in green tissue, chloro-plastids, or chlorophyll granules; and those in coloured flowers and fruits, chromo-plastids. As might be expected from their common .origin, the plastids, which under one set of conditions might become leuco-plastids, may, under another set, become chromo-plastids, etc." The aptness, in plants, for various conditions appears to be due to the 'plastids.'

The chromo-plastids afford examples of structures shewing aptness for various kinds of work which vary according to the conditions which surround them. The *Mimosa pudica*, if well sunned during the day, drops its leaves more readily at night; sunlight makes it apt for

movement. The circumnutation of plants gives them an aptness for those special movements which may result from the influence of light and gravity. We shall see hereafter that the spontaneous movements of children give them aptness for the production of those series of movements which express the action of mind.

Aptness inherited. Aptness to certain conditions is often inherited, that is to say, is due to impressions produced upon the ancestors. Children who inherit a tendency to Myopia develope it more easily during school days than do others. A tendency to certain tricks or habits has often been observed to be transmitted by inheritance. Charles Darwin has recorded many such examples. In such cases the tendency or aptness is inherited, though the condition itself may not be produced.

Logic. Having studied examples of growth for the purpose of aiding our descriptions of man, we pass on to some considerations as to the logic of common descriptions of phenomena in living things; this remark specially concerns speaking of the causes of what we see in Nature. In the descriptions of action in the brain which I shall have to give, the endeavour will be made, not to speak of cause and effect, but of the necessary antecedence and sequence of what we see; and it must always be remembered that the sequence of a phenomenon can never be a part of its causation. It is doubtless true that logic should guide our observations and arguments, but, in some cases, observation, especially as to the time of events, may help to correct our logic.

Antecedent and sequent not to be confounded. It has been said that the daisy opens to meet the rising sun. Observation shews that light must act upon the flower before it opens: light, not a desire in the flower to greet the sun, is the necessary antecedent to the movement. If you assume that something resident

in the flower opens its petals, and if you observe the flower open before the sun illuminates it, then the logic of the statement made above may be correct. It seems that in other cases the assumption of an "It" resident in a living thing may help to put the logic right. This seems to me to be the case in some examples of mental action, as we shall see hereafter.

The child as we see him.

Now coming to the child, as a work of Nature, we have to describe the child as we see him, without making any assumptions, except that the same forces regulate action in his body as in other living things. In this Lecture we study works of Nature at the two extremes of the scale. The modes of Nature's work may be best learnt among the simple vegetable organisms, and the generalisations formed may aid our understanding of action in man. Let us now look at a boy, he is a living thing, he moves, and it is at once obvious that his actions are controlled by sight and sound, as he first follows a butterfly in the attempt to catch it, then comes back when you call him. Look at him—what about his brain, does it act more like a potato or a turnip? It most resembles a potato, for soon you will be satisfied that its separate parts can act independently of one another.

Observing living things.

When we observe a living thing in contrast to an inorganic body, we soon find the importance of deciding as to what separate parts of the object can act more or less independently. Action of any kind, whether growth or motion, can only be observed by our senses in some material part. It does not, however, follow that the object chosen for observation consists of only one part, one and indivisible. Having determined the parts to observe, note the action in each part, i.e. its time, quantity and kind. Then note the sequence or outcome

of the action of each part, and of the series of actions in the whole subject.

Character formed by surrounding influences.

If you accept the views given as to the forces aiding and controlling the attributes and characters of the acts of growth and action, it may appear to you probable that the child trained under certain surrounding influences will be impressed by them, and formed by them, and will subsequently grow in harmony with them; the surroundings largely make the character of the child. It seems to be true that when certain forces have long acted upon a living thing, and have altered its modes of growth or modes of action, that the said living thing remains impressionable to that same force or set of forces. This is in part what is meant when it is said that faculty is increased by use or exercise. In applying such principles it must be remembered that there are internal forces affecting the child's growth and action, but these intrinsic forces, which result from antecedent impressions, may be modified by the environment.

In the next Lecture we shall give particular attention to the study of brain-centres and look at modes of action in them, similar to those seen in lower living things. The brain is one of the most complex organs in the body, we know that it consists of parts which can be stimulated to separate action. We want to study how the brain acts, and in such inquiry our preliminary survey of Nature will help us.

CHAPTER II.

STUDY OF THE BRAIN AS A PART OF THE BODY.

WE now have to study the brain as a part of the body, and determine, as best we may, its modes of action. In the first lecture we observed certain vegetable specimens, which were selected for their simplicity, and we found that it was often possible and convenient to divide the subject observed into parts, which can act independently of one another as to time of action, or unequally as to quantity of action. In so doing we contracted, or limited the field of observation and thought; thus we considered action in individual groups of cells in the radicle of the pea. At other times we found reason to enlarge our field of observation, action in one subject could not be understood by looking at it alone; we understood the flower of the iris better when observing two flowers and a bee. So in now proceeding to study the brain, we begin by dividing it into parts called nerve-centres, which it has been shewn can act separately or in different ratios under varying circumstances.

Widening and contracting the field of observation.

Two flowers and a bee.

Having studied nerve-centres as to their properties, we shall again enlarge our field of observation, including the whole brain, the organs of special sense, and the muscular system which is the mechanism for the expression of thought and action.

Nerve-centres and the brain.

Nerve-cells. *Nerve-fibres.* *Nerve-current.* *Nerve-muscular movement.*

The brain is a soft and delicate structure, seated in the brain case and carefully protected; it consists essentially of two kinds of material, the nerve-cells, and the nerve-fibres. The nerve-cells, when duly nourished, are the makers of nerve-force; for their proper nutrition they need a good supply of blood in their vessels. A nerve-fibre passes off from each cell and conveys the force generated in it, which is then called a nerve-current; there are millions of such cells in the structure of the brain. When the nerve-force generated by a nerve-cell is carried by a fibre to a muscle, say in the face, or in the limbs, this nerve-current causes the muscle to contract or shorten, and visible movement results, the movement being stimulated by the force sent from the nerve-cell. The movement seen, indicates to us the time and quantity of the discharge of force from the nerve-cell; such movement is conveniently called a nerve-muscular movement.

The brain.

The substance of the brain is thus mainly made up of groups of nerve-cells, many of which are connected with one another by nerve-fibres, and many of them are connected with the muscles of the body and send nerve-currents to them, thus causing the movements of the members. The nerve-cell generates force as the outcome of its nutrition. While the brain is giving out force, it must be replenished by nutrition, or it will run down, and be less capable of producing energy after a short time, it will then need food and rest.

Afferent nerve-fibres.

We have spoken of the nerve-cells of the brain as being connected with one another, and with the muscles of the body which produce movements of its parts, it must now be explained that there are other nerve-fibres which connect the organs of special sense, the eye, and the ear, etc., and the skin all over the body, with the

cells of the brain, and convey currents of force from these parts respectively to the cells of the brain; such nerve-fibres are called *afferent* because they convey currents to the nerve-system; in distinction from these the fibres which convey currents from the nerve-cells to the muscles are called *efferent*. The fibres which pass in both directions are collected into bundles, or strings, and are commonly called the nerves of the body; the ingoing or afferent nerves convey stimuli to the brain, the outcoming or efferent nerves carry motor currents from the nerve-cells to the muscles.

Efferent nerve-fibres.

I desire in this lecture to indicate certain characters of the brain as data for the theory of mental action (Psychosis), and explanation of methods of observation of facts, and methods of training the mind, which will be advanced further on.

Visible movement.

The principal method by which we observe action in nerve-centres is by noting their action on muscles; a current passing from a nerve-centre to a muscle is followed by contraction of the muscle, and visible movement in the body; the muscle is the visible index of a nerve-current proceeding from the centre, indicating the time and to some extent the quantity of its action. One set of muscular contractions indicates action in one set of nerve-centres corresponding[1]. Further, the sequence of the muscular action is also the sequence of the action in the centres corresponding, and the antecedent of the action in the centres is the necessary antecedent of the result of the movement. This combined

[1] The clinical investigations of Dr Hughlings Jackson, and the physiological inquiries of Dr Charles Beevor and Mr Victor Horseley, have shewn that while a certain movement is principally due to action in one particular nerve-centre, it may be produced in part by action in other centres.

action of a nerve-centre and muscle is conveniently termed a nerve-muscular act, and such acts are often stimulated through the organs of special sense.

Let me ask your attention to this diagram, it is not a representation of anatomical structure, but may serve our *Explanation of diagram.*

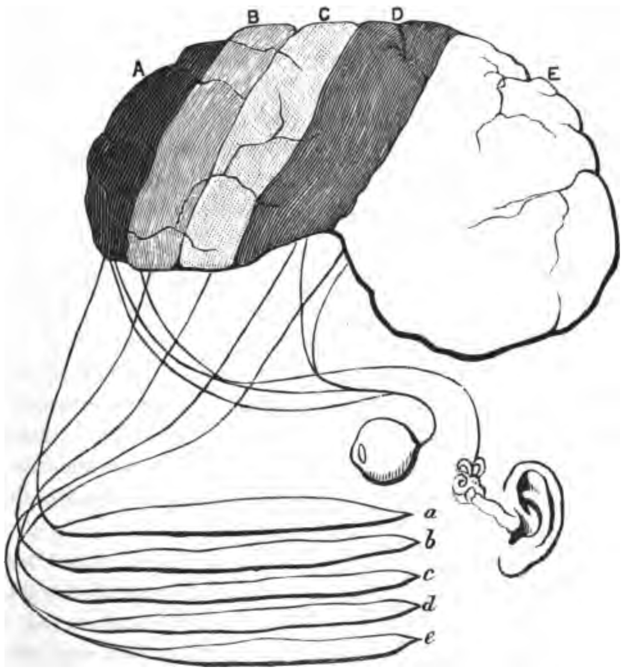

Fig. 1.

The brain is represented by the shading as divided into areas *A*, *B*, *C*, *D*, *E* which can act more or less separately: each area or section of brain is represented as connected by nerve-fibres, with a muscle corresponding. Each section of brain may receive a stimulus from the eye or the ear. The representation is purely diagrammatical for the sake of clearness of description.

present purpose in illustrating some physiological facts. The coloured areas of brain *A*, *B*, *C*, *D*, *E*, each receive fibres carrying impressions from the eye and the ear, so that they can separately be stimulated by sight and sound. Fibres pass from each brain area to the muscles *a*, *b*, *c*, *d*, *e* respectively, so that when *A* is stimulated the muscle *a* contracts, if the centre *E* be stimulated the corresponding muscle *e* contracts, and so on for each centre and muscle respectively, the muscle is the visible index of nerve-currents proceeding from its own centre. If we see the muscles *a*, *b* contract at the same moment that indicates that centres *A*, *B* act together. The nerve-centre must of course be well-supplied with good blood.

'erve-ntres imulated v sight nd sound.

Our primary proposition concerning the stimulation of all vital acts in living things by force from without them, applies to the action of nerve-centres, and is the basis of our theory of mental action. Action in the body has been shewn to be dependent upon muscular contractions secondary to their stimulation by currents from the nerve-centres. The nerve-centres themselves are usually stimulated by sound and sight through the organs of sense.

The nerve-centre is the special seat in which we now desire to study action. In our explanation of the diagram of a nerve-muscular apparatus we speak of (1) A nerve-centre in which action is studied, and the cells which compose it. (2) Its supply of blood. (3) The forces stimulating it. (4) The outcome of action in it. We now have to consider the limit of capacity for action

Verve-entre t work.

in the nerve-centre under given circumstances. The circumstances that may vary are the condition of the centre itself; the blood supply; and the stimulation from without, both in time, quantity, and kind. A child

that is starving from want of food, i.e. a child whose nerve-centres are deprived of due blood supply, does not give out any great amount of force, there is but low capacity for mental and nerve-muscular action. A nerve-centre must be well supplied with good blood in order that it may be apt for action, and clearly impressionable to stimulation from without. In such case the limit of capacity for action is determined by food, and better or fuller feeding may be followed by more action.

Want of stimulation.

The child may be amply fed, but live in a dull dark house, with but few people about to talk to him. Food supply being good in kind, and the supply being regular in time and sufficient in quantity, the cells of the centre also being healthy; then up to a certain point the quantity of action in that centre will be in direct ratio to the stimulation.

Supply of food material.

If the supply of blood to a muscle be constant, as in ordinary health, then increasing the stimulus is followed by growth of its tissue. So if the branch of a tree be bent, causing a congestion of sap, the apples grow larger. If the nerve-centres be well supplied with blood, and have good internal capacity they will act more or less strongly in proportion to the amount of stimulation from without, received through the special senses, and probably such stimulation helps to make them grow. If you believe the nerve-centres to be healthy, and well supplied with good blood, then usually it is well to stimulate them through the senses, that they may grow and become healthy and more impressionable to the environment.

Amount of brain-power.

The amount of work or physical force that the brain can discharge in a given time is limited, but when we come to study the outcome of action of a group of centres then the position is changed. The value of the

work done depends more upon the special groups of cells acting as stimulated by surrounding forces, than it does upon the actual quantity of nerve-force expended, that is to say, the value of brain work depends more upon the impressionability of the brain for co-ordination than upon the amount of physical force discharged. Hence good mental training diminishes the amount of subsequent brain wear.

ponta-eous :tion of erve-'ntres.

Spontaneous action of nerve-centres. I use this term as a label for the subject now before us, but do so under protest of its inaccuracy, and simply for present convenience. I here refer to the tendency to action in nerve-centres, as indicated by movements, when no stimulus has immediately preceded. We saw the so-called spontaneous movements of the circumnutating radicle of a pea. Such movement in the apex of the radicle is said to be spontaneous because it is not immediately stimulated by incident forces or controlled by them—so also with regard to movements in man, many are said to be spontaneous because their stimuli are not immediately antecedent. Spontaneous action of nerve-centres is common in infancy, and returns under depressing circumstances in adult age, as in conditions of exhaustion and irritability. This appears to be a form of lessened impressionability, in such cases, the centre cannot be readily impressed or stimulated by the forces acting upon it.

In observing movements of the body as signs of action of parts of the brain, it is most important to note what circumstances appear to excite the action; if we see no forces exciting the action we call such action spontaneous.

A Nerve-Centre free, or highly stimulated.

Look at a boy playing with a dog while his father calls him to come indoors. He does not do so till the dog is called and runs away from him. *A disobedient boy.*

Now look at the diagram of a nerve-muscular apparatus; it represents two incident forces stimulating the centre, and an outgoing efferent force which passes to the muscles[1]. We have previously shewn that only a certain fixed amount of work can be got out of a nerve-centre by any amount of stimulation. The incident stimulus may determine the time of the outcoming function, and up to a certain point its quantity also. When a centre is being strongly stimulated by one force, the time and quantity of its action are not easily changed by other stimuli. On the contrary, when a centre is only slightly stimulated—say to 40 per cent. of its capacity—it is not only more free or impressionable to alteration of the time and quantity of its action by other forces incident to it, but also the ratios of action are in greater part due to the intrinsic condition of the centres. When the boy was strongly acted on by sight of the dog, his centres were not under control of his father's voice.

A hand free or disengaged is a free nerve-muscular apparatus, with a group of nerve-centres free, say they are stimulated to only 40 per cent. of their capacity. Look at a hand held out to the word of command, or a hand moving towards an object seen; in the latter case it is often less free. This may be contrasted with a hand engaged mechanically in the pocket, or when the person is holding a pen, or pointing to an interesting object. *A hand free for observation.*

[1] Fig. 1, p. 21.

In studying the general condition of the brain, its freshness and aptness for action, its irritability, fatigue, exhaustion, etc., we are really studying the signs, which depend upon the ratios of action, spontaneously occurring in the acting nerve-centres; such observations should be made when the centres are as little stimulated as may be possible from without, for it is the intrinsic condition of the centres we then want to know. It is of course necessary to have the limb, which is to us an index of the brain, mechanically free and unfettered. When we want to study the upper extremity in this way, the limb must be mechanically free, and the nerve-centres as little stimulated as is possible from without. Hence, when you tell the children to hold out their hands in order that you may observe them, let the word of command be as quiet as possible—do not impress the nerve-centres more strongly than need be, because that tends to lessen spontaneity. When a nerve-centre has its functions fully controlled by sound, light does not readily stimulate it, let the sound cease and it is impressionable to sight.

How to observe.

All this is analogous to the seedling pea which circumnutates, or is full of spontaneous movement and is apt for governance by light.

Postures or attitudes.

Theory of Postures. Postures, or attitudes of the body, are very expressive of the condition of brain and muscles. A posture implies the relative position of two or more parts, postures of the hand are shewn in these diagrams, and will be described in Lecture IV. A posture is the outcome of the last movements of the parts, it depends upon the balance or ratios of action in opposing muscles. The quantity of action in each muscle or group of muscles, is determined by the amount of force sent by the nerve-centres corresponding—it follows that

(in a rough degree) the posture indicates the special balance (ratio) of muscular and nerve action.

In observing postures we note the outcome of quantities of force, the quantity of motor power is in some degree a sign of the quantity of action exerted by the nerve-muscular apparatus. The strong clenching of the fist indicates a large quantity of force passing from the nerve-centres to the muscles, producing bending of the fingers. When the fingers are relaxed, this signifies less energy discharged from the centres.

Theory as to double action occurring in a nerve-centre.

Let us look at the diagram representing the nutrition and action of a nerve-muscular apparatus. We assume the apparatus in healthy order and well supplied with blood. A stimulus arrives at the centre, it may be from the ear; action, of some kind, in the centre may be set up thereby, with the result of an overflow of force by nerve-fibres passing to the muscles, followed by their contraction. A double result then may follow stimulation *Double action.* of the nerve-centre, local molecular changes in the centre, and nerve-currents passing from it to certain muscles. When we study movements we study the outcome of the nerve-currents passing from the centres—in studying mental action we shall mainly consider the local, molecular changes in the nerve-centres. The evidence of a permanent local impression is its expression when the subject is stimulated (see delayed expression). Evidence of the local change in the centres is that after the impression produced, e.g., by a word said, there follows immediate action in the hearer, and later, signs of memory of that word are seen. The stimulus of the sound of the word may produce nerve-currents passing from the centre, leading to movements, and also a permanent

impression in the centre itself, such expression of the impression must be by movements as by speech.

Double action as thus explained, does not probably always occur when there is action in a nerve-centre; local action or efferent action may alone result from stimulation. When the eye-ball is touched the eyelids close, the stimulus passes from the eye-ball to the nerve-centre and is immediately followed by movement, and no permanent impression is produced thereby in the centre. When an impression has been produced in a nerve-centre, the time of observation must be prolonged to see if you may find any delayed impression.

Delayed expression. Delayed expression of impressions is very common in mental phenomena, the expression is always by movement. Memory is due to an impression on the nerve-centres; the expression of an impression may be often repeated.

The ratio of the efferent to the local effect may be represented as $\frac{E}{L}$, and the ratio may vary.

Aptness or readiness for action in a nerve-centre.

In order that a nerve-centre may be apt for action it must itself be healthy, well supplied with blood, and not too highly stimulated, then it is ready to respond to a slight stimulus. In many cases a nerve-centre that is acting in a slight degree spontaneously, is very apt for action upon stimulation through the senses. Centres that have often been exercised in various ways are usually more apt for action than those that have not been trained, but the aptness may be diminished by expenditure of their force up to the point of exhaustion. In a child, aptness for action may be reduced by any illness or other condition which lowers nutrition, as

when rapid development of the body is taking place. In congenital defects of the brain there may be very little aptness for any kind of nerve-action.

Retentiveness in a nerve-centre.

This property may best be illustrated by reflex actions. The precision and rapidity of a reflex action shew retentiveness, former stimuli often repeated may produce a very definite organisation in the centre. Retentiveness[1] in the brain leads to the mental faculty called memory.

Inhibition.

By the term Inhibition[2] of nerve-centres, is meant any case where visible movement resulting from the action of those centres is arrested by some stimulus from without. When a child's movements are arrested by speaking to him, they may be said to be inhibited by the sound of your voice. In the next lecture I shall have occasion to refer to this subject again: I believe that the changes occurring among the nerve-centres during inhibition are of the utmost importance, we may judge of these changes by their delayed expression. It is important to note the antecedents and sequents in examples of inhibition.

Exhaustion.

Exhaustion of a nerve-centre may occur from over stimulation and use of the centre; it may result from want of due supply of blood replenished by sufficient food, or from conditions of general illness as by fever. The individual may look well in the face, and yet the nerve-centres may be exhausted—it is then necessary to look to the nerve-centres in action, studying his movements under stimulation, before deciding the state of the nerve-centres.

[1] See *Physical Expression*, p. 234.

[2] See Author's paper in *Brain*, Part XLIII., 1888.

Co-ordination.

A very interesting and important form or mode of impressionability in nerve-centres, is their susceptibility to co-ordination, or functional union for action. When we place an object in an infant's hand, the fingers close around it, grasping the object—this is a combination of nerve-muscular acts sequent to the stimulus of pressure. We infer a combination of acts of nerve-centres corresponding. The stimulus caused by the sound of the dinner bell is followed by certain movements seen in the boy, certain combinations and series of acts. The sight of food placed before him, is followed by his eating it. Sight of the cricket-ball coming towards him, is followed by the combination of movements necessary to his getting ready to catch it.

Hypothesis of co-ordination.

I assume as my hypothesis, that such actions are due to some kind of functional union of the centres produced by the stimulus antecedent to the movement. The act of getting the nerve-centres ready for action, is here supposed to be the formation of some kind of union among the centres, for the passage of nerve-currents through the cells which govern the particular combinations of movements. Referring to the diagram[1]—let *a*, *b* be the muscles acting together to produce the observed movement which follows the sound of the bell. Then, the sound at its incidence to the centres first causes the functional union *AB*, and if the stimulus be strong enough the stimulus is followed by efferent currents passing to *a*, *b*. Let *A*, *B*, *C*, etc. be nerve-cells and *F* an incident force; observation shews that *AB* always follows on action of *F*, and that after a certain number of repetitions, the action *a*, *b* follows the action of *F* with greater certainty than at first, and also that *a*, *b* often occur spontaneously, i. e. without stimulation by

[1] Fig. 1.

F. The assumption is then made that an organic union *AB* has been formed, and that a stimulus acting on either *A* or *B* will cause *AB* to act.

Unions among nerve-centres.

Examples of Unions among nerve-centres are seen in the symmetrical movements of eyelids on either side, and also of the mobile features of the face. We infer that the centres for the two sides of the face usually form a union, for the sound or sight which precedes facial expression, is usually followed by equal and simultaneous movement on each side.

When we observe a case of functional union among nerve-muscular signs, that which we in reality note is special combinations, and special series of nerve-muscular signs. After recording such observations of facts we may infer something as to their causation, and make generalisations. It is very necessary to distinguish in this consideration between our observations and our inferences. We make direct observations upon the child, noting the combinations and series of its movements as it puts out its hand to take an orange. These are nerve-muscular acts, hence we infer the time of the acts of the nerve-centres corresponding. This inference enables us to say that we observe the combinations and series of acts in the nerve-centres. Observing the incident forces we find that upon successive occasions the same series of nerve-muscular acts, or functional unions of centres, occur. Now we may discuss any theories as to the causation of such functional union among the centres.

The evidence as to the functional union occurring is the combination of action, or the series of combinations. We observe the combination of movements and infer combination of action in the centres. The term 'functional union' is convenient, it involves a theory—we must explain rather than define the meaning of the term—

it is an inference from the time of the acts, it is probably the outcome of the common impressionability of the subjects.

As additional evidence that some kind of physical union among the centres is formed, we refer to the following facts:—repetition makes all actions quicker and more precise, they follow more readily and certainly upon the same stimulus; practice makes the actions precise and perfect.

Groups of nerve-centres.

Having thus far studied action in a nerve-centre, and nerve-muscular apparatus, we enlarge our field of observation and shall consider the modes of action in a group of nerve-centres taken collectively. We may study the antecedents and outcome of their synchronous and asynchronous action, their equal or unequal action, and their capacity for control and regulation by incident forces.

In conducting observation as to these characters and results of action in groups of centres, we note the motor action in the muscles.

We have studied 'nerve-centres,' and groups of nerve-centres—it remains to study the brain as a collection of centres. We now speak then of the brain as an organ; we are now enlarging our field of observation.

The brain.

The brain gives vitality; it produces and controls movements and actions, it gives the power of thinking. The brain is impressed by every sight, every sound, every touch, and the effect of these impressions may become a part of the mental faculty. This seems to me to be literally true, and as such adds immensely to our sense of responsibility in the care of children, for it appears that everything our children see or hear, affects their mental growth; let the children see much of Nature and of the best men's work.

Coincident development of Body and Brain.

It is not necessary to give much detail on this subject, and no explanation of the cause will be given. It is an observed fact that to some extent the physiognomy or make, proportions and form of the body, its parts and the features indicate the perfection of construction of the brain. A well-made brain in a well-made body is likely to give the best results under good and wise training. The less good the physiognomy may be, the more need for good education; the perfectly made child, if such there be, still requires careful training, to bring its powers into active harmony with the surroundings.

The great success achieved in schools for feeble-minded children is an immense encouragement to take the utmost pains with feeble children.

Imaginary view of brain in action.

I may conclude this lecture by giving a short imaginary view of what might be seen occurring in a brain in action. It must be understood that this is not a physiological description, only an exercise of imagination in the attempt to put before you in realistic terms a part of what probably occurs.

Imaginary view of brain.

The cell may be imagined as a small viscid mass, from which we see amoeboid filaments shooting out, retracted and lengthening or shortening; thus, adjacent cells may send out fibres, which touching, unite, form a 'tie' or union among cells more or less adjacent, such ties being temporary. It may be imagined that the forming of such unions is accompanied by a flash of pale blue light whenever fibres of adjacent cells unite (mental) and again when unions are broken.

It may be imagined that when vibrations of light or sound act upon such cells, they cause such fibres to be thrown out, or retracted, causing unions to be formed or

broken. It may further be imagined that a definite series of sound vibrations affects, upon different occasions, the same group of cells, and causes in them similar temporary unions. It may further be imagined that sense vibrations, if slight in force, do no more than form such unions as have been described, whereas if they be stronger they may so affect the cells as to cause a nerve-current to pass away from them to muscles producing visible movement in the body. The sound of the word "dog" may produce union among certain cells, the sound of the words "draw a dog" may be followed by the union of many groups of cells, and may stimulate much force in them, overflowing to the muscles which move the upper limb and its fingers, producing an action which results in the "dog" being drawn on paper.

If the cells are healthy, well nourished, and not strongly stimulated, they may spontaneously throw out the fibres and produce unions, and even efferent currents flowing to muscles followed by movements. A union or 'tie' among cells having been formed by some stimulus, currents may flow from it to adjacent cells, forming them into a union, which again forms a third union, which finally sends efferent currents to muscles. The movement will then be an indirect (tertiary) sequence of the incident stimulation.

Brain awaking from sleep.

Look in imagination at the brain of a living child. View the child while asleep, see the body motionless except for the movements of breathing; the brain is simply being nourished, no stimuli reach it by the nerves coming from the organs of sense and no currents pass from it, all is simple, uniform nutrition. In the morning, as sounds impress the ear, afferent currents pass to the brain, certain unions of cells are quickly formed, and currents pass *from them* to certain muscles, there producing visible

movement. Light from the window, and sounds in the house produce numerous currents streaming up afferent fibres, quickly followed by numerous motor unions among nerve-cells, and visible movements as the child wakes up. In the school-room before lessons, we see activity in the brain, numerous flashes of blue light shew the many unions occurring and dissolving among the cells, while the efferent currents pass away to the muscles. Then as he takes his place in class, and the teacher calls for attention, we see him still and quiet, no efferent currents pass to the muscles, still blue light flashes about the cells of the brain as he thinks over the lesson. When he sits and looks at his book unions are being formed in his brain; when told to say his lessons, currents pass from those unions to the muscles which produce vocalization.

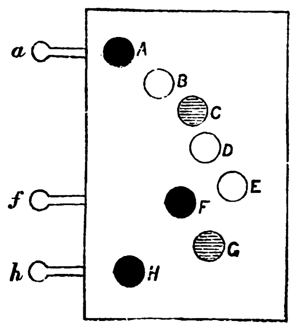

Fig. 2.

In explaining the modes of action of nerve-centres, the Lecturer used a Mechanical Diagram as above, representing a certain area of the brain. The circles represent brain centres; when a centre is presented as black it is sending out force to muscles, and producing visible movement in the body as expressed by elevation of signals at the side, the full action of *A* causes elevation of signal *a* etc.; centres *C*, *G* are supposed to be active but not to be sending nerve-currents to muscles. Centres *B*, *D*, *E* are not acting.

CHAPTER III.

FUNCTION OF BRAIN DISPLAYING MIND ACTION.

Modes of description.

NATURAL phenomena may be described in various ways according to the special purpose in hand, and the object which it is sought to attain. This may be illustrated by the history of the science of botany. In the early period of this science, the object in view was to identify, remember, and name all vegetables. The principal characters used in defining the Natural Orders are based upon the number of parts of the flower, their mutual form, position, cohesion, adhesion etc., i.e. upon structural characters. It is not convenient to use the colours of flowers as the basis of classification. In the early studies of botany the great object in view was to advance the classification and naming of plants, and for this purpose points of structure were noted with the greatest advantage and convenience, the character colour being neglected or considered as quite subordinate in importance to structure.

Natural Orders of plants.

Another mode of classification.

When classes of plants had been arranged, and the individual species described according to structure, and named, it became easier to study the distribution and the properties of plants, and thus new knowledge was gained. Such descriptions are clear, and very useful for the purpose of helping us to determine the order and species of a plant. If the purpose of the naturalists'

studies be to obtain knowledge as to the relations of insects to plant life, then the descriptions which served for the purposes of botanical classification will not suffice. With the change of purpose of study, various other characteristics of the flowers must be observed; colour now becomes of prominent importance. Flowers may be classed according to their colours, and the special insects visiting the red, blue, and white flowers respectively may be noted: thus we gain a new kind of knowledge. *Flowers classed as to colour.*

Let us now turn to the purpose of this Lecture,—the study of the brain as an organ producing the manifestations of mind. The term Psychosis is here used to express the physical processes occurring in the brain which are connected with the action of mind. I have found it convenient to omit from the definitions and descriptions here used, all terms implying subjective conditions which are incapable of direct observation by our senses. I have adopted this plan for several reasons, among others, in the desire to correlate the facts of mental action with other processes of nature, and to trace the effects of the forces around us, which, acting upon the body and the brain, produce aptness for the display of mind. *Psychosis or mental action of brain.*

The study of mental action thus becomes a study of physical facts, as is the study of any other subject in physiology, or the study of the phenomena of light, electricity, or sound. The electrician observed facts, and framed hypotheses to afford explanation of them, hence, we hear his views as to induced currents, Ampère's currents, etc. In studying light the amplitude of waves of ether has been measured. In these branches of science hypothesis has correlated facts, aided understanding, and given definite thoughts which have led to further observation and the acquisition of much useful knowledge. Mental action will be studied by methods *Physico-mental action.*

Mental action studied like motion and growth.

similar to those used in the case of motion and growth. It has been shewn that all expression of mental action is by movement and the results of movement; it will then be anticipated that the methods used in the analysis of movements may be applied to the analysis of mental acts, and that the forces which control and regulate movements also appear to control and regulate action in the brain displaying mind.

I have demonstrated in my Lectures on the Anatomy of Movement, that the actions of man consist of combinations and series of movements, and that they are usually determined by some stimulus from without. It is also there shewn that similar actions, or combinations and series of movements, may occur in different men under similar stimulation.

Movement expressing mental action.

To understand the theory of psychosis which I am about to advance, it is essential to remember what was said in the preceding lecture about double action in nerve-centres and delayed expression. Movements expressing the action of mind, like other nerve-muscular acts, imply local minute change, in the nerve-centres, and currents passing from them to the muscles, the former, or the act of getting the centres ready for action, must always precede the movement: it is this formation for action in the centres, or getting ready for action that I believe to represent the physical act of thought. We cannot define a thought, that is a metaphysical term, we can describe the expression of thought by movement, and may infer the time of the act in the brain centres preceding it. I can only know the thought of another man by its expression in movement, or the results of his movements, the thought precedes its expression. The nerve-mechanism for the thought is probably a part of the mechanism for its expression by movement.

Studying processes of growth in living beings, and movements in man, teaches us much as to action in the brain—observation of the motor action of the brain enables us to make generalisations as to the processes occurring in its parts or nerve-centres. From studying the expression of mind, we shall argue as to the action occurring in the brain which corresponds to the physical action called "thought," which is known to us by subsequent expression in movements. While studying processes of growth in many living things, and movements in man, especially movements indicating mental action, and observing the antecedents and sequents of such acts, I was led to frame a working hypothesis as to the physical action in the brain corresponding to a mental act. *Growth movement. Thought.*

The hypothesis is "That every mental action (act of psychosis), as every motor action, depends upon the formation and action of a certain combination of the nerve-cells." *Hypothesis as to mental action.*

The sum of the phenomena of mind may be considered as a mass of separate mental acts. It is very generally admitted that in some way the organisation and functions of the brain are concerned in displaying mind. It is assumed here, that a mental act is not the act of one mass of brain which does nothing but produce that one thought, but the outcome of the particular set of cells which happen at the moment to act together, the union of cells for such act being temporary though capable of recurring. It has been shewn that one group of cells acting together produces one particular movement, and it is believed that similarly one group of cells can produce one particular act of mind; the particular thought thus depends upon the particular group of cells acting. It is also believed that groups of cells can be

caused to work together for mental acts, as for certain movements, by a very slight stimulus of sound or sight.

Expression of thought always by movement.

The expression of a thought consists in the motor action of a group of cells, the thought (act of psychosis) consists in the formation of the union of cells whose motor or efferent action produces expression of the thought. Thought precedes and is known by subsequent movement; thought is a part of the cause of the movement, and must correspond to some physical (it may be temporary) arrangement among the cells. I do not know what that arrangement may be, but as it leads to associated movements (times of visible action) I suppose that it consists of Associations (unions or ties) among cells, thus "thinking" is the getting ready for action, it is the molecular or functional formation or arrangement of unions among nerve-cells. A special combination or series of movements may occur, and then may not be called up again till some special stimulus recurs, i.e. a special associated action of cells, or union among them, does not recur till that special stimulus recurs.

Hypothesis not final.

These associations, ties, or unions, among cells may be dissolved. The theory given is not a philosophical explanation as to what mind is; it is a temporary working hypothesis, and suggests methods as to the examination of the physical structures concerned in producing the manifestation of mind, and it may help us to see how we can aid such processes in the child.

Mental function due to control of Time.

The mental functions of nerve-centres appear to be merely the faculty for the formation of combinations for action; it is a form of impressionability, such that forces acting through the senses can produce unions among the centres, controlling the special centres in the union, and deciding how long the union shall last, whether it be quickly dissolved or rendered permanent.

See a boy looking long and earnestly at an object that interests him, he gazes at it and is motionless; when spoken to he begins to talk of it, and to describe it, saying what he thinks about it. The boy, while looking at the object, is supposed to be thinking about it; mental acts are supposed to be taking place in his brain; his brain is being got ready for his subsequent speech. We cannot see what is going on in his brain, but when he tells us what he thinks about the object, we have an expression by movement of that which occurred in his brain during his quiet time. The words he now says are the outcome of certain movements of his body, produced by currents from those groups of nerve-cells, which were being prepared by the impression following the sight of the object. The words that come out depend upon the special cells previously arranged into unions. The inference is, that during that wonderful "quiet time", while he gazed motionless at the object, the light reflected from the object got the brain ready, preparing functional unions among its centres. In such a case the expression of what took place in the brain might be delayed; he does not speak, describing his thoughts, till he is questioned,—the mental acts and their expression may be separated by an interval of time,—the impression produced upon the brain is not expressed till it is again impressed by our interrogations.

An attentive boy.

His brain action.

Having explained what is meant by the formation of functional unions among nerve-cells as mental acts, we may study them further, their history and their antecedents. The unions may be temporary or permanent; if temporary, they are considered functional; but if permanent, there seems to be evidence that they may be organic or dependent upon structural union of the cells by fibres which cause them always to act together.

Unions of nerve-cells.

Facial symmetry. Each side of the face may move separately, but in most forms of facial expression the two sides move equally,—the centre for either side can act separately, but usually the two centres form one union in action. The eyes move together in health, the centres forming one union, but under chloroform each eye may move separately[1]. We study the unions of centres by their motor sequence, and also observe the special antecedent; it is probable that all unions of cells for action temporary in duration, whether for mental acts or for motor acts, are brought about by external forces. We take an example of a voluntary act, and an example of ordinary intelligence.

A boy at his lessons. A boy learns his lesson from a book at night and says it in school next morning. While looking at his book, his sight of the book results in certain arrangements among his nerve-cells (*ABC*) such that next day when told to say his lesson, we have expression in the words produced by movement of *abc*. If that has happened in the boy's brain which the teacher wished for, during evening preparation impressions were produced, making functional arrangements among the centres; the expression of such impressions is delayed till the time for saying the lesson, when the word of command is followed by expression of the brain action, and if the lesson be successful, the brain impression, the unions, are rendered firmer and stronger.

Observation of intelligence. I observe my travelling companion, his eyes are directed towards a particular advertisement at several stations; subsequently he speaks to me of the subject-matter of that advertisement. Such action in my companion indicates intelligence. During the time of our journey an impression must have been made upon his centres by the sight of the advertisement. This was a

[1] See *Anatomy of Movement*, p. 33.

functional union of centres (theory) formed by light, "a getting ready", a change molecular in kind, seated in certain nerve-centres, occurring at the time of the impression by light, not at that time followed by nerve-currents from centres to muscles. Such may be called an act of psychosis without expression at the time.

Expression of mental acts.

A mental act is known to us only by the effects (movements) produced by currents passing from this union of cells to muscles. It seems probable, however, that the efferent currents from a union of cells *ABC*[1] instead of passing direct to muscles and producing movement, may pass to other cells, say *A*, *D*, *F*, and from them into a union, which sending efferent currents to muscles *a*, *d*, *f*, produces the movement *adf*, thus the visible outcome is not *abc* but *adf*. To follow out such cases would lead me to branch off into psychology, which is not my present intention. It may be shewn that the expression of a stimulus received need not directly correspond with the impression produced;—the difference is due to the sum of the action of the nerve-mechanisms corresponding to the intermediate acts of thinking.

Antecedents of thought.

The mental acts of which so much has been said, may follow the sight of some object which is said to inspire a thought, or recall one back to memory. If a similar impression be stronger, it may produce a series of movements, or nerve-muscular acts, a nerve-current passing from the union of cells to the muscles.

My purpose in the present lecture is to lay the foundation for a physical study of mental action, and to shew what facts observed in children are likely to advance our knowledge of their mental action; it is not proposed to enter into a philosophical study of psychology, only to illustrate our working hypothesis as a guide to our studies.

[1] See Fig. 1.

My boy, $2\frac{1}{2}$ years old, had been taught to say, "Where are you going to, my pretty maid?" An old gentleman was talking to the child in the park, and asked him where he lived, the boy replied correctly. The gentleman then said, "Who is your father, my little man?" The boy promptly replied, "My father's a farmer, Sir, she said." This is an example of reflex action, not intrinsic in the brain at birth. The brain change giving the mechanism for such reflex was due to the former succession of afferent causes having built up the susceptibility to such reflex.

Mental character of an act due to attribute Time.

An essential feature of this hypothesis of psychosis is, that the special character of the mental act depends upon the attribute time of the action of the nerve-cells. Co-acting or separate action, is merely a question of the time of action whatever the results may be; the relation in time of the action in nerve-centres determines the thought, the time of their efferent action determines the movement. The force which determines the time of action of certain cells, may determine the mental act, or the visible action that follows.

Relation of the known and unknown.

As to the methods followed in this work. We deal with many things unknowable in themselves, and for this reason special methods of argument and inquiry are often needed. As in mathematical processes, so here the unknown is represented by terms or symbols, the relations of these unknowns may then often be demonstrated—thus Time, and Relative quantity may be estimated by experiment and calculation, though their intimate nature be not understood.

Time, Kind, Quantity of acts.

We try to define an impossible knowledge, and to analyse facts to such terms as may be most convenient for our purpose, and then shew the relations among such terms in Time, Kind and Quantity. Thus new know-

ledge may be gained, and a foundation laid for a fresh start in physical research.

Mind not correlatable with force.

One of the principal objections to the view that mental phenomena are in any way directly the outcome of brain action, is that mental work is not correlatable with forms of physical force; the amount of oxidation in the body is not proportional to the amount of mind work. It can be shewn, I think, that this is in accordance with the theory advanced, not opposed to it.

The amount of physical work done by the action of the nerve-cells as represented by oxidation, depends upon the duration of the activity, but not upon the special time of action, or the relation of the time of action of different cells. The amount of physical work done among the cells depends upon the sum total of the action, not upon the special combinations occurring. The value of the acts of psychosis, or of movements resulting, depends upon their sequence, not upon the amount of physical force set free in the cells. It follows that the amount of brain action does not necessarily correspond to the value of the outcome; the regulation of the time of action of centres, or their co-ordination is a physical phenomena, but is not a display of force that is correlatable with mechanical work done.

Mental action and physical wear.

Let us assume that there are *n* centres by means of which mental acts can be produced; according to the hypothesis the number of distinct mental acts possible depends upon the possible number of combinations that can be formed out of *n* factors (i.e. $2^n - 1$); 20 nerve-centres may be arranged in 976,255 different combinations, the action of any one of these combinations produces an act of psychosis; but the social or intellectual value of these acts may vary immensely.

If there be three centres capable of performing

mental acts, there are seven possible arrangements of co-acting A, B, C, AB, AC, BC, ABC, O.

Now it may be assumed that the centres A, B, C, each consume in action a similar amount of oxygen, then AB, AC, BC each requires the same amount of oxygen, viz. twice as much as A, and ABC requires for its action three times as much oxygen as is required by A alone. Now the intellectual value of the thought corresponding to the action of AB, AC, BC may vary greatly, though each act consumes the same amount of oxygen. The use, and social or intellectual value of an act of psychosis need not depend upon the physical force expended in its production, this is analogous to what is seen in the motor outcome of the brain. In many forms of manual work, such as carpentry, we value not the number of foot-pounds of labour performed, but the cunning of the work done, the outcome of the special series of motor acts.

Social value of an act.

Value of a telegram.

The value of a telegraphic message does not depend upon the quantity of chemical action in the battery which produced the electrical current conveying the message.

With n nerve-centres the amount of their oxidation in an hour, just as the cells of a battery, depends upon the length of time the separate cells have worked, not at all upon the special combinations of action that have occurred. A time bill may be made up against each cell and the total action of n cells during one hour's thinking may then be cast up.

Wear in a galvanic battery.

The cell oxidizes only while acting as in a Léclanche's battery, each cell oxidizes only while acting.

An hour's hard intellectual work may mean many thoughts, or many combinations formed and dissolved with great rapidity, which would not necessarily correspond to a high time bill for the centres at work.

Another objection that may be put forward against our working hypothesis is—How is it that original thinking takes so much of our mental energy? *Original thinking.*

Probably in such kinds of thinking, many thoughts or acts of psychosis are performed with great rapidity, and only suitable ones survive or are preserved. In this original thinking much action occurs in the process of forming new combinations. Original thinking exhausts greatly, rapidly limiting the capacity.

In some way, I know not how, in original thinking, intrinsic forces (which are always weak) build up the unions of cells and thus the weak intrinsic forces are soon exhausted.

In receiving a new idea by reading it is not so, the process is less exhausting. To read an original book is to have unions effected in one's brain by an incident force, the light impress off the printed page. To reproduce the ideas previously read, is not to originate these arrangements of centres by the weak intrinsic forces; they have been previously formed by the incident light impress of the book. *Reading new work.*

Similar phenomena might be quoted with regard to auditory impressions; a tune once heard is readily reproduced by one who could not originate the tune without notes.

The hypothesis that has been given as to what occurs in an act of psychosis, harmonises the attributes of an act of psychosis with those of movement, and enables us to study the effects of those forces which alike produce co-ordinated acts of movement and the signs of mental action. A co-ordinated series of movements takes long to learn, a series of thoughts may take long to fix in the memory, but when either series of acts has been produced, it is more easily reproduced than before. *Mental action and movement.*

Deductions from hypothesis. If my hypothesis be accepted, certain conclusions may be drawn. We will make some deductions from the hypothesis; we suppose that there is either action or no action in the nerve-centres we deal with, we are not speaking here of quantities of action, only of the time.

If 5 centres act they may form 31 combinations, no more.

If n centres act they may form $(2^n - 1)$ combinations, no more.

Look at the table of combinations of 5 terms, you will find that each term occurs in 16 combinations—to give formula;—each term occurs in $(2^{n-1} - 1)$ combinations. Thus A occurs in 16 combinations. Now if one of these centres be incapable of acting, it reduces the number of possible combinations by one-half. Every additional nerve-centre doubles the number of possible unions, so that 20 centres may produce 976,255 unions, but 19 centres can produce only 488,128 unions.

Extent of vocabulary. It is said that an ordinary farm-labourer uses a vocabulary of about 300 words, that Shakespeare's vocabulary contains about 15,000 words. If it be assumed that each word corresponded to an act of psychosis, we use the following formula:

Formula. Let A=number of combinations observed, x=number of centres forming these combinations,

$$A = 2^x - 1 \text{ and } x = \frac{\log(A+1)}{\log 2}.$$

In the case supposed $A = 15000$ for Shakespeare, $A = 300$ for labourer. Thus Shakespeare must have had at least 14 centres, and the average farmer has not less than eight.

Again referring to the table of combinations of five centres, if the action of each cell produces an equal

amount of brain wear, the combinations are not of equal value as to wear.

Single	*A, B, C, D, E*	5
Binary	*AB, AC, AD, AE, BC, BD, BE, CD, CE, DE*	10
Ternary,	*ABC, ABD, ABE, ACD, ACE, ADE, BCD, BCE, BDE, CDE*	10
Quaternary	*ABCD, ACDE, ABCE, ABDE, BCDE*	5
	ABCDE	1
		31

A mode of mental action may now be considered which seems to be the normal in young children, and is not uncommon in adults when fatigue has lowered the mental power. The term Micro-psychosis is here used to imply the brain action which corresponds to the earliest forms of thought in the child, spontaneous or uncontrolled by impressions from outside. Observation of the child's spontaneous movements shews that spontaneous combinations of nerve-centres are formed, and it may be shewn that spontaneous movements and irregular uncontrolled thoughts often occur together in children. I imagine that in this state the nerve-cells concerned in the display of mental action act more or less separately and independent of control by the senses, as in the spontaneous movements of the infant (micro-kinesis), and that their co-ordination as development proceeds, produces the definite mental acts called thoughts. We do not speak of the infant's early movements as 'actions,' and the earliest formations of unions among its nerve-cells cannot be called thoughts. As rough analogies—a child is fidgety (full of uncontrolled movements) and is inattentive (thoughts uncontrolled); during sleep impressionability is lessened, and dreams are spontaneous.

Vague thoughts exhausting.

Spontaneous thinking and moving.

A fidgety child.

Nervous imaginative children. Nervous children are full of spontaneous movements, and often have many strange, disconnected, imaginative, precocious thoughts. In adult life these are wandering, unbidden, wild, ungoverned thoughts, a mass of thoughts, a cloud or rush of thoughts through the brain. In healthy people these are best controlled by things seen and heard. This micro-psychosis is fatiguing, and may result from exhaustion.

Instinct and intelligence. Let us consider the conditions commonly called instinct and intelligence. Acts due to instinct may be performed at birth; the chick pecks its way through the shell, then it soon pecks crumbs off the ground. The arrangement of nerve-cells in the chick causing these acts exists at birth, and such acts are called signs of instinct because they depend upon congenital arrangements. Intelligence is an after-birth development; the nerve-arrangements for its display are largely built up in the child by the impressions that it receives from without. The congenital mechanism is called instinct, the outcome of impressions produced after birth is called intelligence.

Intelligence due to many brain properties. Intelligence, in as far as it is due to brain action, is not due to one property in the brain, but to many properties, vitality, nutrition, the power to stimulate muscular contraction, susceptibility to impressions from without, and chiefly to the facility it possesses for the formation of unions for action among its parts, such being produced by the agency of the senses. Each of such properties is possessed in some degree by other things besides the brain, but the brain alone possesses them all in a high degree. This is the reason for asking you to study Nature's work in other living things beside the child.

CHAPTER IV.

OBSERVATION AND DESCRIPTION OF FACTS.

WHEN you give a description of your observations in a child, it is well to commence by stating under what circumstances your observations are made, and the previous occupations of the child. Note approximately, or by actual measurement, his height and weight, and the complexion and colour of the hair and eyes. At the same time note the form, proportions and general make of the body. Thus:—he may be tall and thin; short, stout, very fat[1], or coarsely built and clownish[2]. Much has been written by authors on physiognomy, about the proportions, the size and the form of the head; observe well-made children, and contrast them with the less favoured. Study good works of art, and thus train *How to observe a child.* *Value of works of Art.*

Cases.

[1] A big fat boy aged 12, in Standard II., the biggest boy in the class. Looks of low type, with coarsely made lips. Hands both in the "Nervous type posture"; coarse horizontal frontal creases. Some jerky movements of the head, with some irregular movements of the trunk. He was reported in the school as dull, not troublesome. He was a big fat boy of low brain-power and mentally dull.

[2] A boy age 13, Standard III. Head wide, and lower jaw large, features otherwise normal. Expression good. Horizontal lines on forehead from over-action of the frontal muscles. Weak hand posture with lateral twitching of fingers. Well nourished. Dull and lazy. A boy of low type.

Both these boys certainly require education, but they may be unfitted for the work of the ordinary standards; probably some form of manual training would be the most suitable for them.

yourselves to know good types of human form, when you see them.

The head. As to the head, estimate or measure the circumference, note the height of the vertex above the level of the ears, the position of the greatest transverse diameter, the facial angle and the build of the forehead; it may be high, broad and ample, or low and contracted between the temples. *Defects.* As defects, the head may be too large and flat, with a very projecting forehead due to early rickets; it may have a raised seam down the middle, or it may be lumpy; these are defects. The texture and arrangement of the hair may be worthy of notice, so whether it cease in a sharp line at the forehead, or cover that part as a soft long down. *The features.* The separate features must be described. *Ears.* The ears should be symmetrical, but one or both may be misshapen, contracted in the rim, or otherwise defective. *Mouth.* The mouth may be large or too small[1], with thick, coarse lips, or they may be thin and well cut. Eyelids sometimes have a vertical fold of skin at the inner angle (epicanthus), like that seen in some of the Japanese races; *Epicanthus.* this is a defect. The cheek-bones may be high and prominent. *Skin.* A good skin is thin, bright and clear, not too pale, and shewing a play of colour, especially if the complexion be fair[2].

Cases.

[1] *Report on Schools*, p. 8.

[2] 809. A boy 7 years old, Standard I. Epicanthic folds slightly marked, openings between eyelids (palpebral fissures) and the mouth too small. He was a fat boy and shewed no obvious nerve-defects. His work in school was average, but he was known as a boy who would fight in the streets.

609. A girl aged 10, Standard V. The head was big, forehead wide and bulging in the upper part. Palate high and narrow; ears normal; she was thin. Hands "nervous type of posture," finger twitching. She was mentally very bright, but not perfectly well developed and distinctly nervous.

Now turning to the signs of the action of the nerve-system upon the body. The trunk should be erect and symmetrical, well curved and mobile, with the head balanced erect on the top of the spine.

A boy aged 10, Standard IV. Head long from back to front (dolicho-cephalic) and lumpy. Upper forehead protuberant without bosses. Palate narrow and high; features good. The muscles in the forehead were over-acting, producing horizontal creases. He was pigeon-breasted from the effects of rickets; thin in the limbs, but not in the face, and of good colour. Teacher said he was a good boy and rather above the average in intelligence.

As to the significance of defects of the head and features much information may be gleaned from the Report of observations in schools.

Defects of head.

Visible defects of the skull were seen in 231 children (boys 166, girls 65) out of the 5,344 (boys 2,794, girls 2,550) examined. The coincidence of "signs of nervousness, nerve-weakness, or defect," "low nutrition" and "mental dulness" as reported is shewn thus:

	Boys.	Girls.	Total.
Badly-made heads with signs of nervousness, nerve-weakness, etc.	59	25	84
,, ,, ,, ,, low nutrition . .	43	24	67
,, ,, ,, ,, mental dulness .	52	19	71

If you want to study examples of badly-made heads, look for them in the boys' school, where they are most abundant.

Defects of ears.

As to the significance of defects of ears, this defect is to be rated much lower in value than badly-made heads. In the Report there are 81 cases (boys 64, girls 17) with defective ears.

Defect of ears in combination with:

"Nerve-signs" in boys 24, girls 5, total 29.

"Low nutrition" in boys 17, girls 4, total 21.

"Mental dulness" in boys 24, girls 4, total 28.

These conditions, e.g. Nerve-signs, Mental dulness and Low nutrition, often coexist in the same case.

In 73 cases presenting other visible defects than those given above we found as follows:

"Nerve-signs" in boys 23, girls 4, total 27.

"Low nutrition" in boys 10, girls 4, total 14.

"Mental dulness" in boys 18, girls 4, total 22.

Postures and movements.

Postures and movements are signs of action in the nerve-centres; they are direct outcomes of nerve-currents passing from the centres to the muscles; both classes of signs may be observed in such parts of the body as can move separately. It will assist future descriptions if I here give some typical postures. There are four principal postures of the head—flexion, a bending forward on the breast;—extension, or bending of the head backward, as in gazing upwards;—rotation to one or other side in a horizontal plane, the head remaining erect, but the face being turned to the right or left;—inclination to one or other side, lowering that ear so that the two do not remain on the same level,—inclination is said to be towards that side on which the ear is lowest. The posture may be compound, the head may be flexed, inclined and rotated to the right, or it may be extended and inclined to the left, etc. The same terms as those here employed for differing positions of the head may be used in describing its movements; it may be flexed, inclined, etc.

Postures of head.

How to observe the hand.

When about to observe the spontaneous postures assumed in the arms, or upper extremities of a child, I ask him to stand up, and explaining what is meant by the palm of the hand, say—"Put out your hands with the palms down, spreading the fingers,"—speaking in a quiet tone, and not shewing my own hands. It is then possible to notice the postures of the body, the head, and the spine, the arms and the hands, as well as the movements of these parts. This action of the child is convenient, leaving the arms and hands free, and ready for observation and description.

Straight hand.

The typical hand posture seen in health and strength, is the straight extended hand. The fingers are straight *with the palm* of the hand, and on a level with the fore-

arm and shoulder, the palm of the hand, or metacarpus, is straight, not arched transversely, or contracted as in

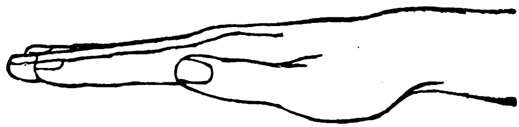

Fig. 3.—STRAIGHT EXTENDED HAND.
Hand digits and bones of palm in same plane with forearm.

the feeble hand. All parts are in the same horizontal plane.

The second typical posture is but a slight deviation from the first; the thumb with its metacarpal bone being

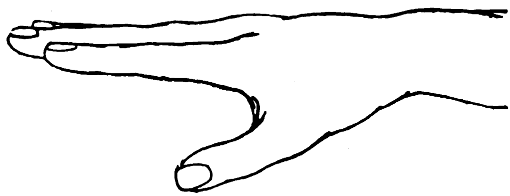

Fig. 4.—STRAIGHT EXTENDED HAND WITH THUMB DROOPED.
Same as above, with thumb and its metacarpal bone drooped or partially flexed.

drooped, all other parts being on the same level as before.

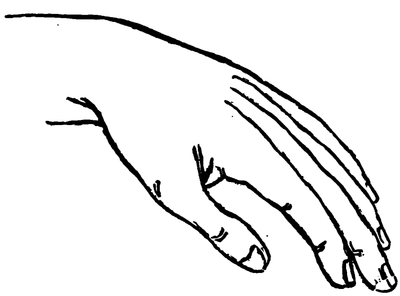

Fig. 5.—HAND IN REST.
Slight general bending (flexion) of all joints, palm very slightly bent or contracted.

The hand in rest is the natural posture when it is not being energized by the brain.

There is slight flexion of the wrist and fingers, and slight arching of the palm of the hand.

The energetic hand is a posture produced under moderately strong brain stimulation. The wrist is extended, the fingers and thumb being moderately flexed.

Fig. 6.—ENERGETIC HAND.
Wrist extended; digits somewhat flexed.

The four typical postures that have been given are normal as signs of certain healthy brain states.

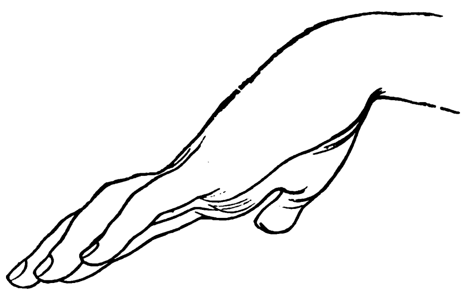

Fig. 7.—NERVOUS HAND.
Wrist flexed; palm somewhat contracted; fingers extended backwards at knuckles, or meta-carpophalangeal joints; thumb *extended.*

The nervous hand is due to an abnormal brain state, an ill-balanced condition of the brain centre. The wrist is flexed, the metacarpus slightly contracted, the thumb somewhat separated from the other digits, the fingers and the thumb are bent backwards at the knuckle-joints. This posture is directly opposite (in direct antithesis) to the energetic hand, the wrist and knuckle-joints being in exactly opposite positions in the two attitudes[1].

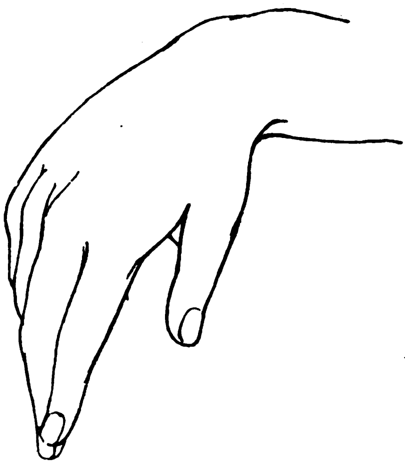

Fig. 8.—FEEBLE HAND.
Wrist and all joints more flexed or bent than in C.; palm or metacarpus much contracted.

[1] Comparison of the "Energetic hand" and the "Nervous hand posture" affords a good example of opposite (antithetical) postures; look at the position of the same joints in the two cases. *Opposite postures.*

	Nervous hand.	Energetic hand.
Wrist	flexed	extended
Knuckle-joints	extended	flexed
Joints of fingers	flexed	"
Thumb	extended	"
Relative position of the fingers	slightly separated	slightly drawn together

The feeble hand presents moderate general flexion; this is seen in the wrist, thumb and fingers, the palm of the hand being considerably contracted, thus approximating the thumb and little finger. It probably represents the least possible amount of force coming from the nerve-centres to the muscles of the limb; muscular tone is here lower than in the hand in rest.

The convulsive hand. The closed fist, or the clenched hand, has the fingers strongly drawn over the thumb, which is pressed upon the palm of the hand. The palm is contracted, or drawn together.

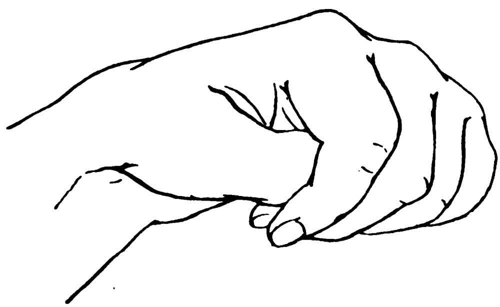

Fig. 9.—CONVULSIVE HAND.
Palm contracted, thumb flexed on palm and fingers flexed, *i.e.* closed fist.

These postures are opposite one to the other, and so are the conditions in which they occur. The nervous hand posture is seen in weak and excitable children, the energetic hand is seen in a strong and eager child, who signifies his readiness to answer a question by holding out his hand, or in a little child running to his father. In an antique gem may be seen the engraving of a warrior lifting up and playing with his infant son, whose hands are both in the energetic posture. So ancient are the present modes of expression in man. In the bronze statuettes of the Hamilton collection at the British Museum we see to-day Venus represented with the nervous hand. Drawings of similar modes of expression may be seen on *the Etruscan* vases. See *Physical Expression*, p. 300.

To complete the types, the hand in fright will be described, but I do not think it is often seen in real life. The wrist is extended as well as all the fingers; this posture thus differs from the energetic hand only in the character of extension of the fingers[1].

Fig. 10.—HAND IN FRIGHT.
Wrist extended; palm straight, fingers and thumb extended straight.

[1] The hand postures most commonly seen in schools are the "Nervous hand" and the "Weak or feeble hand"; their relative frequency is thus given in the Report of 5,344 pupils.

	Boys.	Girls.	Total.
"Nervous hand" in	69	74	143
,, with twitching of fingers	21	18	39
,, with arching of the back forwards (Lordosis)	16	30	46
,, with horizontal creases in the forehead, shewing frontal muscles over-acting	16	1	17

Finger twitching. While observing the hand posture of the child you are describing, look also for any finger movements[1].

In speaking of symmetry of postures of the body, we must take separately the median parts and the limbs. The head, when held erect, is in a symmetrical posture,

Examples.

	Boys.	Girls.	Total.
"Nervous hand" with relaxation of circular muscle of eyelids	5	4	9
,, without other nerve-signs	32	31	73
"Weak hand" in	26	28	54
,, with twitching of fingers	6	8	14
,, with arching of the back forwards (Lordosis)	4	9	13
,, with horizontal creases in the forehead, shewing frontal muscles over-acting	9	1	10
,, with relaxation of circular muscle of eyelids	3	4	7
,, without other nerve-signs	10	11	21

[1] The hand when held out should be steady, but it is not uncommon to see twitching movements of the fingers in young children and in nervous pupils. These twitching movements may be in flexion and extension, or lateral; the lateral twitches are less common but are more indicative of an over mobile brain. Remember that every twitch you see corresponds to the discharge of a weak nerve-current from some centre in the brain. The number of twitches in each hand should be looked to: these movements commonly accompany the "nervous hand posture."

	Boys.	Girls.	Total.
"Finger twitchings" were seen in	45	37	82
,, ,, with "Nervous hand"	21	18	39
,, ,, ,, "Weak hand"	6	8	14
,, ,, ,, Lordosis	7	11	18
,, ,, ,, frontals over-acting	11	2	13
,, ,, ,, relaxation of circular muscle of eyelids	3	3	6
,, ,, ,, without other nerve-signs	11	8	19

so also when it is flexed or extended; to produce such balance, both sides of the brain must act equally, and at the same time. If the head be rotated to the right, this indicates more force sent from the left half of the brain than from the right; asymmetry of posture means unequal action of parts of the brain. Similarly unequal action and asymmetry of posture may cause the spine to bend over to one or other side, this is very commonly seen in weak children. If the two arms be held out, we may see a posture of weakness on one side only, more usually in the left hand, or the characteristic posture may be more strongly marked on one side. Thus we frequently see the nervous-hand posture strongly marked on the left side, and less distinct on the right, thus indicating a different balance of the action of the corresponding nerve-centres on the two sides. All postures are the results of the last movements of the parts, and indicate ratios of nerve-muscular action; movements in the parts of the body are the direct outcome of the nerve-currents passing from the centres to the muscles. *Asymmetry of balance.*

Description of movements. In describing movements, we must indicate the parts moving; in the upper extremity we have the upper arm, the forearm, the bones of the palm of the hand (metacarpus), the thumb and fingers; movement can only occur at a joint, so the movement of the joint defines the movement. We speak of movement of the shoulder, elbow, wrist and knuckle-joints. There is a different physiological significance in movement of large joints, such as shoulder and elbow, from that implied by the movement of small parts, such as the fingers[1]. Move-

[1] Spontaneous movements of small parts are often signs of a very mobile brain or indicate nervousness, fatigue, etc.; the repeated similar movement of larger parts, as shrugging the shoulders or rotating the head, often indicates some defective condition or pecu-

ments of the eyes are movements of small parts, in comparison to those of the head and trunk. If corresponding parts on opposite sides of the body move synchronously and equally, their movements are similar and may be called symmetrical, as indicating similar action in either half of the brain. Having noted the part moving, the direction of movement must be indicated, the terms used have been given.

Time of movement.

The movement itself as seen, has only two attributes, time and quantity. This matter has been fully discussed elsewhere (Anatomy of Movement). As to the time of a movement, we may note the time of day when it is seen, its duration, and the frequency of its repetition, as well as what circumstances precede it, and what results from its action.

Quantity of movement.

The quantity of a movement is in part indicated by the amount of displacement, or distance through which the part moves. The interval of time between the stimulation preceding the act, and the act itself, is of great importance. So much as to the attributes of a movement; in practice you will often see many movements at the same time; many parts moving together in groups, or in series. What is commonly called an action, as carving, or writing, is an observed combination, or series of acts or movements[1]. A child sees an orange; he seizes it and eats it. This action seen in the child is a series of acts or movements, each of which can be performed separately, and the character of the action

A child seizing an orange.

liarity of development. The changeful expression of the face is a series of fine movements; in contrast we may see frequent grinning or frowning as a sign of defective make.

Speech.

[1] Speech is a series of movements, the chatter of children is equivalent to their other spontaneous movements; the words uttered are produced by numerous small movements and frequent repetition may occur.

depends upon the time, and the quantity of each of the component movements. It is the sight of the orange, the impression produced by light reflected from the orange, that is the antecedent of this series of movements, controlling their time and order, and the quantity of each component movement. Coincident movements may be of many or of few parts. In giving a description of what you see in a child, note whether many or few parts move together, whether one, two, or all the fingers open and close together, and whether similar parts move on either side.

Coincident movements.

A movement of part of the body is a physical fact; when you have observed it, try and make out what was its necessary antecedent or exciting cause. Movements are commonly stimulated by impressions made upon the senses by light, sound, or touch. Feeding may lessen or increase the number of movements, hence observe the effects of taking food.

Movement—its antecedent and sequence.

Movements are the facts we are now dealing with as signs of brain states; certain movements of parts, and groups of parts of the body, which are commonly met with, are deserving of special description.

The face is a very accurate index of the action of the brain. Either side of the face can move separately, and the various mobile features may have separate action. To examine a face in detail, hold a sheet of paper in front of it, with one edge vertical covering the median line; either half of the face can thus be examined in turn. Again, the face may be divided into three zones, or horizontal areas—the upper, middle, and lower. To define each in turn, hold the sheet of paper with one margin horizontal, leaving the forehead above the eyebrows uncovered,—this shews the upper zone; next view only that part of the face which is below the lower

The Face.

margin of the orbits, or sockets for the eyes, shewing the mouth, the greater part of the cheeks, and the openings of the nose,—this is the lower zone. Lastly, the middle zone may be demonstrated alone by holding the horizontal margin of one sheet of paper so as to cover all above the eyebrows, and another covering the lower zone. A few words may be said as to movement in each part as defined.

Facial symmetry of movement.

The two sides of the face usually act together, each corresponding part on either side moving in equal degree; i.e. movements of the face are usually symmetrical. In three rather low class expressions, viz. winking with one eye, one-sided grinning, and in sneering or uncovering one canine tooth, we see asymmetry of facial movement.

The muscles in the frontal zone produce furrows in the skin in two directions, horizontal from side to side, and vertically towards the centre approximating the eyebrows[1]. When you see such action, note if it is apparently produced by a strong light, or whether it appears to be spontaneous. A large circular muscle closes the eyelids, but this muscle has other interest for us; its tone varies greatly according to the state of brain power; when this is low, this circular muscle is toneless and

Frowning.

[1] If you observe these points often, and in many children, you will soon learn to put a different value upon the two classes of action. Horizontal creases in the forehead are produced by action of the frontal muscles: over-action of these in a child's face is a rather low-class sign, as may be judged of by the following facts. In the Report on children in 14 London schools we note 124 cases of "Frontal muscles over-acting" (boys 109, girls 15, total 124), but they are very unequally distributed among the two groups of schools.

10 Public Elementary Schools shewed 43 cases out of 3,931 children. 4 Special Schools shewed 81 cases out of 1,413 children.

These 4 Special Schools are a large pauper school, school for *the Deaf and* Dumb, and two Certified Industrial Schools.

relaxed. In a strong and healthy face, the lower eyelid appears clean cut, and the rotundity of the eyeball can be seen underneath it; when the circular muscle is relaxed, the skin of the lower lid bulges forward, the under eyelid is full and baggy, or swollen; this is common in exhaustion with a tendency to headaches[1]. If you make the child laugh, you temporarily energize this muscle, and the appearance described is temporarily lost. A low tone of this muscle may lead to the eyelids being partially open during sleep.

Fulness under eyes.

Value of laughter.

The parts about the mouth move in eating and in speaking. The angles of the mouth can be drawn upwards, downwards, or outwards widening the mouth. The strong circular muscle of the mouth can draw the lips together, and thrust them forward in pouting.

The varying expression of the face is due to variations of movement, however slight they may be; an expressionless face is one that does not move and vary in the tone of its muscles. The liveliness of the faces of children is due to every changing muscular tone movement occurring as often as in the fingers and other parts. In analysing faces it is necessary sometimes to observe the tone of the skin. I often examine the parts of the face with a magnifying glass to determine the tone of the various facial muscles.

A face may look bright or dull; several elements tend to produce such appearances. The colour of the face, in as far as it is fixed, is due to pigment in the

A bright face.

[1] 829. A boy 11 years old, in Standard VI. No defect in physiognomy, except that the right ear is not well shapen. He is overmobile, and says himself that he is clumsy at home. The circular muscle of the eyelids is relaxed while he is at his work, but recovers a good tone when he is spoken to. Physical health and nutrition appear to be average, and teacher says he is intelligent.

skin; the colour that comes and goes from the skin and lips is due to action of the nerve-system upon the super-ficial blood-vessels. Ever varying expression is another element in the brightness of a face; but besides these factors, we have the form and fulness of the tissues of the face, as mainly determined by its amount of fat. Slight degrees of emaciation make the skin dull, it becomes full of minute creases on the surface; when fat increases it brightens again. A dull face suggests weighing the child, but do not take the face alone as an index of nutrition, look also to the arms and legs, they may be thin when the face is fat.

A dull face.

A long face.

A face may be long, actually longer than it should be, owing to the jaw being depressed or fallen, and also from a general relaxed condition of the muscles. From what has been said it appears that when we look at a human face we see its form or physiognomy, and the signs of brain-action produced by currents passing from it to the muscles. We see something more than this however, all previous mobile expressions of the face have left their mark behind, and have stamped an expression of the character of the man.

Blushing.

We cannot leave the observation of the face without some reference to blushing. The heightened colour is due to the increased blood supply in the small vessels of the skin; the increased flow of blood is determined by certain nerves, termed "the sympathetic," whose action often corresponds with those brain states which accom-pany the "emotions." When blushing is seen, search for the cause, if no determining antecedent is apparent, it is probably due to a mental condition, try to find out what this may be.

The Eyes.

Passing on to speak of the eyes—I refer to the eye-balls, not to the eyelids which cover them. The eye-

balls are seated in their sockets, the orbits of the skull, resting among the fatty tissue which supports them. If that fat be diminished in quantity, the eyeball sinks back into the orbit; if the fat becomes congested and swollen up, it protrudes the eye somewhat. The movements of the eyes are effected by small muscles attached to the eyes, and to the walls of the orbits. The eyes move together, so that when one turns to the right, so does the other. In looking at near objects, say at nine inches from the face, the eyes turn slightly, but equally, towards one another. *Movements of eyes.*

The action called staring may be due partly to the eyeballs being immovable for some seconds, and partly to retraction of the upper eyelids. Each element should be observed separately. In noting movements of the eyes, distinguish movements of the eyes in the orbits from turning of the head with the eyes towards the object looked at; the two acts are different. Movements of the eyes in the orbits indicate action of small muscles; movement of the head is effected by larger muscles. The infant often moves its head without moving the eyes; movement of eyes in the orbits is the greater sign of intelligence. *Staring.* *Movements of head and eyes.*

Movements of the eyes are not equally common in all directions, more movements occur in the horizontal direction than in the vertical. When the eyes turn towards objects, this is due to their muscles being stimulated by brain-currents, generated by the sight of the objects. In observing movements of the eyes, notice whether they are obviously guided by sights or sounds around, or whether it be not so. Movements of the eyes not controlled as to their number and direction by obvious circumstances, present or antecedent, must be called spontaneous, and looked upon as signs of ner- *Direction of movement.*

5—2

Wandering eyes. vousness. Irregular movements of the eyes are common in children, and are very significant of their brain condition; they may be looked upon as analogous to spontaneous twitchings of the fingers. The size of the pupils of the eye should be observed; if it contracts to light; its size may also be determined by the brain state.

Full-face and profile view. When the child stands up and holds out his hands, it is well to get both a full face and a profile view, and look for any movements there may be, noting the part moved, and the direction of its movement. The finger movements may be in two directions—they may be in flexion and extension, or they may be lateral; these latter are performed by smaller muscles, and are most important signs of irritability of brain. The flexor-extensor movements can be seen in full face, or in the profile view; the lateral movements of the fingers are best seen in front of the child. Looking at movements of the digits, note whether the separate parts usually move together or not, the constant repetition of one series of movements is often very senseless. In nervous twitching it is more common to see one or two fingers only moving, corresponding to discharge of nerve-currents from small brain areas. There may be movements of the palm of the hand, extending and contracting it.

Having spoken of movements in various parts of the body, let me direct your attention to what are commonly called the 'kinds,' or special characters of the movements seen.

Spontaneous movement. Spontaneous movements. The term implies that no special antecedents have been determined for such movements, stimulating the nerve-centres—they are supposed to have no special relations to the surroundings. Such movements are constant in infants and very young children, becoming less spontaneous and more controlled by

sights and sounds as growth and development advance. Movements are described as twitchings, when quick and seen in small parts, not effecting any useful purpose. Tremor is a term applied to the rapid and uniform movement of a part, the displacement being but slight; tremors are often of a rate of over 200 per minute.

Reflex movement.

Reflex movements refer to the action of a special nerve-muscular apparatus, an afferent nerve-tract, and the stimulus acting upon a sensory surface followed by movement. An essential character of what is commonly called a reflex movement is, that the movement quickly follows upon the stimulation, without any perceptible interval. If the eyeball is touched, the eyelids are quickly closed; this movement, and this alone, follows the impression produced as a reflex action. It will be seen that common reflex movements thus differ considerably from those we shall speak of as signs of intelligence.

Movements indicating intelligence.

You may observe certain movements, which are said to indicate intelligence; such are the most interesting, but the most difficult to define. It seems that the purposive, or intelligent character of a series of movements is not due to its intrinsic attributes, but to its antecedents and sequents. The ordinary respiratory movements are not signs of intelligence, but when they are modified by sights and sounds around, as speech and laughter, they may indicate intelligence. Without giving an exact physical description of what is meant by intelligent movements, it may be said that their outcome is in harmony with the impression producing them. All movements in the body, however they be classified, are physical phenomena, and are due to physical antecedents.

Voluntary movements.

Voluntary and mental movements. Movements when studied as signs of mental action are often said to be

voluntary, more or less voluntary in contrast to others described as automatic or spontaneous. Probably we cannot define a voluntary movement, but we may explain what conditions observed make us call it more or less voluntary. A movement following upon a word of command may be considered voluntary. Respiratory movements when occurring in a uniform series are not considered voluntary, but when the action is specially modified, as in speaking, or in singing, where the action is regulated by the sound of music, they are more voluntary. The movements of respiration in the infant are uniform, except when the child cries as an expression of pain or other mental emotion; in the adult many forms of emotion are expressed by variation in respiratory action, as in fear and anger. The modified respiratory actions termed sighing, laughing, singing, etc., may be signs of mental states, because they indicate nerve-states modified by special circumstances or antecedents. We consider such signs as mental phenomena, not so much on account of their (attributes or) intrinsic characters, as because of their relation to antecedents—the previous sight or sound. When no special antecedents of the act of sighing are known it is often said to be spontaneous, automatic, or involuntary. The voluntary character of a movement appears to be indicated partly by its relation to some antecedent impression and in part by its sequence. Useful acts are often considered to be voluntary, and these are such as produce some result. The voluntary character is also in part due to its control by some impression in place of spontaneous action; it may also be due to a change from one series of acts to another. In other cases the voluntary character is admitted because the act is obviously an example of delayed expression of some previous impression. As examples of voluntary

Mental acts are usually spontaneous movements modified.

The voluntary character.

and intelligent action, see—the ready reply, the exact copy, the act appropriate to the circumstance.

Series of movements. A complex series of movements of many parts in succession, i. e. a compound series of movements following some slight stimulus through eye or ear without reinforcement of brain action and producing some result or impression, is usually intelligent and voluntary; the more distinctly we see the action controlled by circumstances without reinforcement the more is it like an intelligent and voluntary action. *An intelligent cat and a dog.* We see a cat sitting on the doorstep of a house, a dog comes by, the cat simply moves behind the railings without any excess of movement or display of emotion—that is a voluntary and intelligent act, the outcome of experience or previous impressions.

Study of children's brains. Observation, comparison, and accurate study are necessary in order to understand what is going on in children's brains. Looking at the whole body as to movements occurring in its parts, compare ratios of action in parts corresponding on the two sides; consider the ratio of movements of small parts to large parts in the arm and the head—the number of movements of digits in relation to those of the wrist and elbow, compared with movements of the eyes in relation to the head, etc.

Physical signs. In this lecture, physical signs which you may observe have been indicated, without any reference to their significance. This has been done intentionally; I desire that you should observe facts, then think about them and draw conclusions.

In the next lecture, descriptions will be given of various conditions seen in children, the terms employed being such as have been enumerated above.

CHAPTER V.

DESCRIPTION OF VARIOUS CONDITIONS IN CHILDREN.

We commonly speak of various conditions as seen in children, such as consciousness, sleep, fatigue; such names are of scientific value when we have determined their physical connotation, or the physical signs by which we recognise the condition; each such term stands in place of the group of signs which express the condition. The most important condition of a child's brain is that indicated by the signs of *Consciousness*. You will find that the movements accompanying and expressing consciousness are such as are stimulated by circumstances acting upon its brain through the senses. If speaking to the child, or shewing him objects, is followed by his speaking, or by his hands moving towards the object, he is said to be conscious, or if he subsequently speaks of the object, he is said to have been conscious when the thing was presented to him, because we see that his nerve-centres were impressed by the sight of it. If at night you stand by his bedside while he is sound asleep and unconscious, you see general absence of all movements except those of breathing; if you speak to him in a low voice, or hold a toy in front of him, he does not speak or move. There may be some movements of his limbs, or fingers, but such are not determined by objects around, they are not the outcome of impressions produced from *without* at the time of your observation.

Consciousness.

Sleep.

Such absence of movement in a child when spoken to does not necessarily imply sleep, he may shew the signs of sleep given above, but next day he may repeat what you said to him when he was quiet, proving that he was impressionable, and that an impression was produced, but that the expression was delayed. Absence of movement in sleep indicates that nerve-currents are not passing, at any rate not with great strength, from the brain to the muscles. Nutrition of the brain is probably going on uniformly throughout, but no expenditure of force is taking place. It is often said there may be different depths of sleep; sleep may be full and complete, with loss of most forms of impressionability. In healthy sleep the tone of the circular muscles of the eyelids is sufficient to keep them closed, but in some weakly children they remain half open, shewing a part of the white portion of the eye[1]. If you gently raise the arm, by one finger in the wrist-band, the hand of the child in sleep falls into the posture of rest (see fig. 5); there may possibly be some twitching of the fingers. You may hear the child grinding his teeth, this is not a good sign. Tooth-grinding is due to the united action of the muscles of mastication moving the lower jaw; these muscles are supplied by the motor division of the fifth nerve of the brain, and the sensory fibres of that nerve supply the membranes of the brain, as well as parts outside the head. Tooth-grinding shews brain irritation. Dreams may be supposed to trouble a child when he cries out during his sleep, but the words he says may have no relation in fact with his work during the day. Restless nights mean a brain not perfectly nourished during sleep. The importance of imperfect sleep is to be measured by sequential

Little force expended in sleep.

Depth of sleep.

Tooth-grinding.

Dreams.

[1] See *Anatomy of Movement*, p. 33, as to eye movements in sleep.

signs of fatigue and irritability. Sleep is essentially indicated by lessened impressionability, and diminished flow of nerve-currents to the muscles, the face becomes less mobile, the head falls forward, the circular muscles of the eyelids overcome the elevators of the upper lids, the eyelids close and the body may fall if not supported—the child is asleep. Healthy sleep is followed by much spontaneous activity and increased impressionability.

Fatigue.

Fatigue is the name given to the condition which follows exertion, it is removable by rest, but if not relieved, passes on to exhaustion. Among the visible signs indicating fatigue in the individual, I may mention the slight amount of force expended in movement, and the small number of movements. There appears to be a lessened total of force passing from the nerve-centres to the muscles. There seems to be general evidence that lessened force in the brain is apt to be followed by asymmetry of action, the two sides not acting equally; the result is asymmetry of postures, and unequal movements in the two sides of the body. Nerve-centres when weakened by over-work are often irritable, giving out force on the slightest stimulation, or upon no apparent stimulation. As you look at the child you see too little movement, or occasional jerky movements, not controlled by circumstances. The balance of the trunk and head is probably asymmetrical, probably the head is inclined to one side. The arms, when extended, may not be on the same level, the feeble hand or other weak posture, is seen, possibly, with some finger twitching. The eye-movements may not be distinctly fixed by the sight of objects around; the face is less lively looking, less mobile, possibly there may be fulness under either eye, owing to a relaxed state of the circular muscles of the eyelids. You will, of course, note the circum-

Asymmetry of balance.

Feeble postures.

Wandering eyes.

Facial expression.

stances under which those observations are made, that you may determine the cause and remove it. In the state of fatigue, the body comes more directly under the influence of gravity; if work be persisted in by the student, the body should be supported as by an appropriate chair; food may be needed.

Exhaustion. If expenditure of force continue after fatigue has existed for some time, the more severe condition termed Exhaustion supervenes. In the movements that occur there is very little force, and they are not well under the control of the senses; the balance of the body is asymmetrical, the head may hang too forward, and to one or the other side, the spine be too much bent forward in the loins (Lordosis), and bent back in the higher part. *Bent spine.* Putting the hands forward causes much alteration of the balance of the trunk; the feeble hand or the nervous hand may be observed probably with finger twitchings in flexion and extension or in lateral movements. The eyes probably wander; the face is motionless and pale, often the under eyelids are full and puffy. The face may be elongated from relaxation of its muscles and slight falling of the jaw, the mouth being partially open. The ordinary movements of expression are not excited by the ordinary stimuli, and such movements as do occur are slow and delayed. *Want of impressionability.* The face may have a dull appearance from ill nutrition and shrinking of its fat, and the eyes may be slightly sunken from the same cause.

A stronger stimulus than usual is required to induce the child to hold out his hands, the feeble or nervous posture is then seen with ill balance of the head and spine. *Sighing and yawning.* Sighing and yawning are spasmodic movements common in exhaustion, speech may be slow, and the voice altered in tone or even lost. In exhaustion we

Exhaustion. often find that the nerve-centres are too ready to send out currents to the muscles without being stimulated, and the time and quantity of their action is not determined by circumstances around. A slight noise may make him start; on the other hand, speaking to him may not be followed by a ready reply, the useless starting movement is in excess, the reply we want cannot be got from him. You will find it difficult in this condition of the child's brain to form any new organization for movements, or to get him to learn anything. Further, there may be a tendency to an action, the opposite to that usually under the circumstances—an inverted ratio of action among the centres. *Unusual action.* When irritable, a child may turn his head away from the sight of objects, which in happier moments he would look at. You say he turns his head away from his dinner because he is irritable and peevish; his nerve-centres turn his head away at the sight of food because they are not in good acting order. Reflex action is usually in excess in the state of exhaustion, movements upon touch are excessive, hence it is not well to try and impress the child much when in such a condition.

Irritability. The condition termed irritability in a child is usually an accompaniment of fatigue or exhaustion. Such state is indicated by the following signs; a slight noise makes him start, this is a reflex movement in excess, a reflex action that does not occur in the more perfect condition of health under such stimulus. In irritability other stimuli besides sound may produce excessive reflex action; a touch upon the shoulder is followed by a sudden movement. Not only is the amount of reflex movement excessive, and out of due proportion to the stimulus, but the kind of movement may differ from that usually following such a stimulus under better conditions

of the nerve-system. A child three years of age, when irritable, may turn away his head from a familiar object such as usually attracts his attention, or from the sight of his food, and say "no, no"; here the sight of the object, instead of causing a reflex movement of head, eyes and hands towards the object, moves them all from it. The irritability of the nerve-centres is indicated by movements in the opposite direction from that which the same stimulus would produce in a more restful condition. Besides these reflex signs we find the voice altered, when spoken to he may answer sharply; the motor force generally is lessened and irregular in kind; twitching irregular movements like the spontaneous movements of younger children are not uncommon in this state of "irritability," which seems to be a condition of reduction to a more infantile state. Nervous children often shew marked signs of irritability, the spontaneous postures assumed are those of fatigue, with the addition of slight irregular twitching movements. This irritability may result from exhaustion, and like explosions of passion, it may lead to exhaustion. Abnormal conditions in the body, particularly in the stomach, may render the child irritable, so may fever or other illness. The child that is irritable may require rest and feeding; inquire as to his sleeping, and do not try to produce much impression on him while in this state by talking.

Irritability.

Voice altered.

Irritability results from exhaustion.

It produces exhaustion.

Fatigue and exhaustion are best removed by feeding and rest. Restfulness implies recreation of the parts fatigued or exhausted; the nerve-centres are the parts most needing rest after work, and these do not all get equally tired. One occupation exercises or tires one set of centres, a different occupation may exercise another set of centres and allow the first set to rest; reading may be followed by writing, and this exercise by singing,

The remedy.

which employs the respiratory nerve-apparatus. On the other hand the centres concerned in mental work may alone be fatigued, as indicated by the eyes not being readily drawn to the work, and by uncertainty of reply to questions, and delay in replying. The nerve-muscular apparatus concerned in active play may be found in good order when the lesson is finished.

Rest. Complete rest is needed at times; the whole of the body and brain at times require to go through a period of quiet nutrition, without any expenditure of force that can be avoided. This may best be effected after feeding, when the blood is rich with nutritive material. The signs of restfulness are negative, absence of movement, as in sleep, indeed this state differs from sleep only—we will not say in the retention of consciousness but—in the signs of impressionability; the child when resting speaks if spoken to, and is impressed by what he sees and hears. To procure complete rest, let the sources of impressions be removed from around him. It has been said that the signs of rest are negative; that rest has been effected is known by subsequent activity, an increase of spontaneous action, greater capacity for the proper functions of the brain, and the removal of all signs of fatigue.

Rest, not insensibility. *Rest* is a condition of nutrition leading to the signs of recreation indicated by subsequent activity. The most essential element in the expression of the condition rest, is the subsequent activity. During rest there is still impressionability which affords a distinguishing character between simple rest and sleep; arising out of this we have the fact that in rest uncomplicated by sleep, the eyelids usually remain open.

One of the special characters of rest is the absence of movement, although impressionability is retained. Rest is usually preceded by fatigue, and it is followed by

activity ; the sequential signs of recreation and activity indicate that during the period in which movement was absent there was rest. Rest is expressed by the present signs of rest, followed by the signs of recreation and activity.

As a matter of interest it may be noted that forces, such as the sound of soothing music, may affect movements. Music may cause a man to keep quiet and rest. In contradistinction to the state of rest we have activity. The condition of activity is indicated by actions, i.e. movements. In activity with strength, the movements are probably fewer in number than in the state of irritability, and the kinds of movement differ in the two conditions. *Value of music.*

One sign of healthy activity is a quick response of movement upon stimulation, for example the movement follows quickly upon the sight of an object, or on hearing a sound. If such movements are looked upon as reflex actions, the quick and ready answer is a reflex series of movements when the period of latency is short; this of course implies also that impressionability is good. *Healthy activity.*

The necessity for alternation of activity and rest in training young people arises from the fact that each is necessary to aid the nutrition, growth and development of the body and brain.

The signs of nutrition are so important, that although the subject has been touched upon, I must speak of it again here. A well-nourished body has a weight and height equal to that of the average for the age, the proportions of the various parts are the normal, the skin is of healthy colour, and the tissues beneath it are firm, the face is full and bright. A body thus well nourished is not necessarily possessed of a well-nourished brain, a body badly nourished is probably never possessed of a brain well nourished, for this, of all the parts of the *Nutrition.*

Nutrition of body and brain. body, suffers the first in conditions of depression. The state of the brain must be observed independently of the rest of the body of which it is a part: look to the various signs of brain action as they have been described. When brain action is defective, observe how impressions are produced upon it by sights and sounds, it may not be sufficiently stimulated by the events of daily life, and need special training.

Signs of nutrition. Nutrition may be expressed by (1) form or growth, and (2) by motion which is due to nutrition.

As evidence that motor signs, or movements and the results of movements, may express nutrition, let us examine a few examples.

(1) In an ill-nourished infant spontaneous movement is much lessened or the child may lie almost motionless, instead of being constantly full of movement while awake. The return of spontaneous movement is a sign of the improved nutrition.

(2) In a man after a severe illness, such as a fever, the tone of the voice is usually altered so that we can no longer recognise the individual by his voice, this motor sign as well as the worn countenance indicates the man's lowered nutrition. Returning health is shewn by the patient "looking like himself" and "recovering his old voice."

(3) In a child seven years old emaciation, and ill-nutrition, indicated by loss of weight, may be accompanied by St Vitus' dance or finger twitching, which disappears when weight increases and nutrition is improved.

(4) A strong well-nourished man is less fidgety than a weak one. Now as to the expression of nutrition by form and growth, proportions of growth often indicate conditions of nutrition.

A seedling pea-plant if kept in a room with deficient light is not well nourished, and the ill nutrition is indicated by the small yellow leaves and the long white stem. That good nutrition has not occurred during the life of the plant is demonstrated by the fact that the plant when dry weighs less than the seed from which it grew. Here ill nutrition is expressed by the relative growth of leaves and stem, the leaves being very small, the stem very long. In children we often see growth for a time occur in height without lateral development, then the proportions of growth change, and the child fattens. *Nutrition of a seedling.*

The signs of nutrition must be observed not only in the face but also in the limbs, the face may be of good colour and fat, but the rest of the body may be thin. Low nutrition may depend on many causes, among others it may coexist with defects of development, as is shewn in the table on defects of the body given below. *Look not only at the face.*

Nutrition is often low in ill-developed children, such as those with poor physiognomy, or defects of the head or the features. Referring to the Report on Schools we find an analysis of 231 children (boys 153, girls 78) with cranial abnormalities, i.e. badly made skulls, of these signs of low nutrition were found in 67 cases (43 boys, 24 girls). *Observations.*

In such cases good feeding may be helpful, but this alone will probably not cause the children to be well nourished.

As coincident conditions with low nutrition as seen in 184 children (100 boys, 84 girls) we found:—

	Boys	Girls	Total
Low nutrition with signs of nervousness, nerve-weakness or defect	46	42	88
,, ,, cranial abnormalities	43	24	67
,, ,, mental dulness	40	29	69

Headaches. Headaches often accompany signs of exhaustion. You cannot see the headache, that is a subjective condition; it is not well often to ask children as to their feelings, the outward manifestation of their brain state is of far greater importance. I usually consider the accompaniment of headaches probable, when a child presents the signs to be given as characteristic of the nervous condition. Headaches in children may be excited by defects of eyesight, which can be detected on careful examination; and corrected by the use of proper glasses; *Spectacles.* such correction may remove the headaches, and also prevent development of squint. Headaches may be produced by want of ventilation in living and sleeping rooms, by injudicious feeding, and by overwork; it must always be remembered that head-pain is common in cases of brain disease. The tendency to the development of nervous headaches is often inherited, such known tendency should forewarn those in charge of the child; suggesting, not neglect of education, but early detection of the signs of brain fatigue, and avoidance of exhaustion. Exhaustion may be produced at home or at school, late dinners and late hours lead to asymmetry of postures, nervous twitchings, and fulness under the eyes next day, grave defects in the eyes of all who look to the future happiness of the child.

Mental excitement. Suppose a boy is observed while making a speech in a debating Society—one person says "he shows much mental excitement"; another says his speech is rapid and the same words are frequently repeated. The right foot is planted firmly, the right arm is raised free from the body and the fingers move much, while the left hand rests firmly on the table at his side; there is much movement of individual parts of the face but action is here symmetrical; the eyes are moved frequently both

laterally and sometimes in the vertical direction as he continues speaking, while the head is occasionally extended the muscles of the forehead contracting the while. The sight of people around and their occasional remarks do not control his action; and when his left hand is raised it gesticulates frequently though in less degree than the right. When louder remarks among his audience do produce some impression upon him, the indications thereof immediately follow, and the retort is not delayed. At last the words said and his visible action markedly differ from those usual under such circumstances, or his own at other times.

Signs of excitement.

As a summary, or definition of this condition, we may say, "It is a condition indicated by rapid cerebral action, with some repetition, unequal action occurs in the two hemispheres of the brain; there is much movement of small parts with cerebral reinforcements, diminished aptitude for control, much spontaneity, while the action following upon stimulation is often different from the normal, and the outcome of any impressions received is not delayed[1]."

Brain condition corresponding.

Let me describe a typical example of a nervous child. Complaints may be made of a child that he sleeps badly, talks at night, grinds his teeth, emaciates, although there is no disease of any of the organs, often suffers from headache, and is irritable, though quick in mind and affectionate. Let such a child stand up, and observe him. As to conditions of growth, defects of proportional development are commonly seen. The form and make of the head, and the features, as well as the characters of the skin may be good. The height of the child in relation of circumference, or to weight, is defective, the child is too tall and too thin; either fat or muscle, or both, may be defective in quantity. The

A nervous child.

His make of body.

[1] See Author's paper, *Journal of Mental Science*, April, 1889.

emaciation may be unequally distributed, often it is less in the face than in the limbs and trunk.

Signs of brain action.

Now as to the motor signs indicating the state of the nerve-system. Let the hands be held out with the palms downwards and the fingers spread. The left upper extremity is probably at a lower level than the right; "the nervous hand" is seen on either side, perhaps more marked on the left; there may be finger twitching, separate digits moving in flexion and extension, or laterally. The head is slightly flexed with some inclination and rotation usually to the right. The spine is arched too forward in the loins, often with inequality in the level of the shoulders, and slight lateral curvature. The face as a whole, is too immobile, although there may be some over-action of the muscles widening the mouth, on one or on both sides. The eyes move much, mostly in the horizontal direction, these movements not being fully controlled by the sight and sounds of objects around, except under strong stimulation. The tongue, when protruded, is too mobile; some of the teeth are usually found ground at their tips, this is most commonly the case with the canines.

Such a child should be watched carefully as to matters of health, he should rest much, and never be allowed to get exhausted by work, play, or late hours.

An inert child.

Certain general conditions of the brain will now be described in terms which indicate points for observation. A child is said to be *inert* when slow in all his movements, each movement itself being slow, the formation of compound movements (associated movements), and the time of action after stimulation being all behindhand. In such a case look for signs of defect in make of the features; signs of ill nutrition and exhaustion; in any case a wisely conducted training is specially necessary

to aid brain development. In such a child you will want to see signs of increasing brain power, quicker movement upon stimulation, the action being more exactly and quickly controlled by the eye, and the ear; greater strength for fatigue; greater capacity for the formation of the groups of movements or unions among nerve-centres. Increasing brain development is also shown by lessened spontaneous movement, as the child grows up, concurrent with increase of intelligent movements controlled through the senses; the power to sleep and rest should remain unimpaired.

Training aids development.

The indications of mental anxiety and bodily pain may be compared. In looking at children it is well to see what is wrong before trying to find out its cause. Looking at the face you may see an average or fixed expression, principally located in the frontal zone, as vertical furrows, not apparently due to present impressions through the senses, but apparently a delayed expression of long antecedent impression. Such usually indicates a brain state corresponding to mental anxiety or pain as distinguished from suffering due to states of other parts of the body. Such observation in the face of a child would suggest searching for its cause; of this I shall speak again in the last lecture. Suffering produced by some part of the body, at the time of observation, is indicated in the lower part of the face by depression of the angles of the mouth; depressed angles of the mouth suggest enquiry as to some cause of pain, or something acting, and about to produce an outburst of crying. In searching for a cause of the expression of mental anxiety, watch the face as you touch upon various subjects in conversation; see what increases, or what diminishes, the appearance; it may be that all conversation lessens the appearance of anxiety, which returns the most when the

Mental anxiety and bodily pain.

Expression of a sad memory. child is left unimpressed, then it is probably due to some fixed thought or fear. In the condition of mental pain, corresponding to a memory or a sad thought, the expression there is written in the forehead, the eyebrows being drawn together with vertical creases. I have seen a class of boys all (corrugating) with their eyebrows thus knit when hard at mathematical work. A placid face with changeful expression is an index free to show us varying brain states.

Signs of joy. The signs of joy have been well described by Sir Charles Bell[1]. "In joy, the eyebrow is raised moderately, but without any angularity; the forehead is smooth, the eye full, lively and sparkling; the nostril is moderately inflated, and a smile is on the lips. In all the exhilarating emotions, the eyebrow, the eyelids, the nostril and the angle of the mouth are raised. In the depressing passions it is the reverse. For example, in discontent the brow is clouded, the nose peculiarly arched, and the angle of the mouth drawn down." In Bell's account of joy, the first paragraph is in terms of nerve-muscular movements; then comes the paragraph "the eye full, lively and sparkling," this is an artistic expression I fail to analyse; does the 'full eye' mean a condition of parts outside the eye? Does the term 'lively' apply to a muscular condition? Does the 'sparkling' eye depend on tension due to muscular action? I trust that further knowledge may enable us to include these under our principles of expression.

Analysing Bell's description we find then that with the exception of one paragraph the terms used all imply movements and results of movements.

Laughter. If we take Charles Darwin's description of laughter, we find it given in terms of movements, as are almost all his descriptions of expression.

[1] *Anatomy and Philosophy of Expression*, page 172.

"During laughter the mouth is open more or less widely, with the corners drawn much backwards, as well as a little upwards; and the upper lip is somewhat raised. The drawing back of the corners is best seen in moderate laughter, and especially in a broad smile—the latter epithet showing how the mouth is widened....Dr Duchenne[1] repeatedly insists that, under the emotion of joy, the mouth is acted on convulsively by the great zygomatic muscles, which serve to draw the corners backwards and upwards; but judging from the manner in which the upper teeth are always exposed during laughter and broad smiling, as well as from my own sensations, I cannot doubt that some of the muscles running to the upper lip are likewise brought into moderate action. The upper and lower orbicular muscles of the eyes are at the same time more or less contracted: and there is an intimate connection, as explained in the chapter on weeping, between the orbiculars, especially the lower ones, and some of the muscles running to the upper lip." *C. Darwin on laughter.*

What good, what advantage is there in these special modes of describing what we see? Our modes of description are such as allow of comparisons being made. We translate abstract quantities such as 'joy' into concrete terms, such as movements, or conditions of form or development. We translate the terms used to describe the abstract property, into other terms the expression of the abstract. The term 'happiness' is intended to indicate a certain condition of feeling which we all more or less understand; the thing happiness is an abstraction, but if we can define an expression of happiness in man, we can deal with the material expression of happiness, analyse and study it. Having these descriptions before *Advantage of correct descriptions.*

[1] *Mécanisme de la Physionomie Humaine*, Album, Legende VI.

Comparison of various states. us we can make some comparisons, or analogies. In laughter, which is an expression of joy or happiness, the angles of the mouth are drawn upwards, this is the very opposite to the expression of physical suffering. By defining the expression of the abstract thing happiness in terms of motor signs, we find problems to deal with, capable of physical investigation.

Science and Natural History help those who observe. If you desire to get help from physical science in educational work, you must observe physical facts and give your descriptions in such terms only as indicate what can be observed by physical processes. In truth you must avoid metaphysical descriptions in scientific work; study Nature's works and write the history of all you see, expecting facts to be repeated under similar conditions.

Teacher impresses his class. In observing the children, and searching for the conditions which produce in them what you see, remember that the principal sources of impression in a class are from the Teacher. Observe the effects of your own actions, especially your words of command and varying *Word of command.* tones. Such stimulation acting upon children may change at once their facial expression, and remember that to alter a child's face has a secondary effect, altering its face by your command reacts upon its brain and alters its mental state. A bad face, put on for fun, is apt to call up bad feeling; a good face, produced by imitation of yours, helps to raise in the child a "good state of mind."

Imitation. Imitation is a principle that serves to explain many phenomena that you see in children. I have touched upon this subject just now, but must say what facts appear to be included in this term, and what physiological conditions correspond. If a child sees the teacher make a certain movement, and he does the same, that is imi-

tation—the sight of your movement brings into activity the same combination of nerve-centres as you use. This is one means by which you determine action in the child's brain.

Conditions to look for. In trying to observe, look for:—the signs of impressionability, retentiveness, inhibition, spontaneity, double action and delayed expression[1], and thus judge whether there be a progressive increase of capacity for brain action. The signs of these conditions have been given in earlier lectures.

Groups of children. Looking at groups of children associated for purposes of education, other considerations must engage your thoughts and direct your observations. Note specially any children above or below the average size and age, looking specially to see how such arrangement has come about either from natural or artificial causes, and whether it is working to the advantage of these particular children, and that of the class as a whole.

Look for fatigue. Study the children individually, and look for any signs of fatigue before and after lessons, look at them while teaching, when they are preparing lessons, and when they are at play.

School conditions. Condition of each child. Study the surroundings of the class, and as far as possible, the surroundings of each member in his or her individual life. Much has been said and written about the construction, ventilation and adornment of schools, as well as about the arrangements of desks and seats.

All matters of domestic and school hygiene are of great importance, but do not come within the scope of my present purpose.

[1] Descriptions are given in the text, references may be found in the index.

CHAPTER VI.

METHOD.—MANAGEMENT AND PRACTICE.

Teacher's duty to train.

THE duty of the teacher seems to consist of two parts —the training, preparing and continuously improving himself and his methods of practice; and secondly, teaching and training the pupils. The teacher who does his full duty, will study the children, training himself to know what to observe, and how to think about his observations; and will acquire such general knowledge as may enable him to decide what to do under the circumstances.

I suppose nobody can make an intelligent effort to teach others, without at the same time learning something himself; it will then not be necessary that I should separate what has to be said about learning for ourselves, and teaching and training others.

I do not speak as being myself engaged in teaching boys and girls, but for many years I have closely studied them, and have also been engaged in College teaching, and University examinations, etc.

The child at school.

Let us commence with the child on arriving in the schoolroom. The teacher looks at each member of the class, thinking more about them than of the lesson, and continues to observe them closely during lesson time. I have dwelt upon the importance of observing and describing actual facts occurring in children, as far as they *are* observable.

Say you are thinking about a child who gives trouble from being fidgety; you observe the movements which indicate the fidgetiness, the parts that move principally, whether hands or feet, whether one or both sides, thus looking to head, face, eyes, limbs, etc. As to the results of these movements, they are such that the class cannot be allowed to be so disturbed. Thinking about the child, you recall other conditions of excess of movement. You look to the antecedents of this fidgetiness, and under what circumstances it increases or diminishes; thus you will gain knowledge for future use in management. Fidgetiness may occur in healthy children when exhausted, when long confined in close rooms, or when wanting food. Commencing chorea may be mistaken for mere fidgetiness, it is very often one-sided. *A fidgety child.* *Causes.*

The boy is peevish, apt to mutter and complain, silly and childish—carefully observe him; all reflex-actions are wrong, call him and his head turns away, when you speak to him, no reply comes, when you say nothing, out come his complaints. His phrases are simple, disconnected, and like those used by a younger child. The boy is for the time reduced, or turned back to the brain condition of a baby. There are some spontaneous movements, these are but little controlled by his surroundings. Let him be quiet, while he sees others happy and at work, imitation may make him seek to join them. In such brain condition, an important sign of return to baby-like condition is the limitation of vocabulary and repetition of words. Food in such cases is useful, especially beef-tea, which is stimulating. *A peevish boy.* *Management.*

Irritability of temper may result from exhaustion, and it may produce exhaustion; in such conditions look carefully for antecedent conditions producing them. Do *Irritability from exhaustion.*

Irritability may produce exhaustion.

not let children look ill-tempered, the facial expression tends to raise the feeling.

I do not wish to appear to say that all child-faults are due to weakness, and even those that are must be corrected and overcome.

Lying.

Lying in children, especially the petty untruths of word and action in young children, appear often to coincide with two forms of brain condition that can be dealt with; over-mental activity not as yet trained to precision in action, and the condition of brain which leads to the manifestation of fear, timidity and confusion when suddenly spoken to.

Signs of timidity and mental confusion.

The latter brain state is indicated by many reflexes being out of good working order; the door slamming makes him start, he likes to be quiet; when someone enters the room suddenly, he drops his book and then says he didn't. Do not call that lying, give him time, be very quiet, and do not produce any strong impression on him by what you say as—"is he not a nervous child?" If well managed, all will come right. In such children the sense of an injustice is often keen. Such cases differ greatly from deliberate lying to gain an object in a child who has no signs of physical defect.

Inattention.

The cerebral condition producing inattention may be due either to change in the brain tissue itself, or to conditions in its blood supply. Where there has been prolonged absence of food, the blood is proportionately poor; when heavy food has been taken, the blood is drawn away from the brain to the digestive organs. On the other hand, the brain may be fatigued as the result of much force given out from it. Inattention is, I suspect, much more often due to the brain being impressed by other things than those which should at the time attract the attention and impress it. The brain is not *free and* disengaged, as it was shown in Chapter II., it

must be in order that it may be duly impressionable to stimulation from without. It may be under the impression of the sight of some object, or the impression of a previous game, or an arrangement made for one to follow school walk.

Hysteria. In speaking of hysteria, I shall not give a medical description of the condition so termed, but the following signs may lead us to anticipate a tendency to hysteria. Such children are over-mobile, fidgety with their fingers, and fidgety with their dress; the eyes may be restless, and other signs of nervousness may be seen. *Signs of predisposition.* The eyes may be restless, the postures of the head, hand and spine asymmetrical; there is laughing in undue amount, and other expressions of emotion upon any impression, the tendency to laughter being contagious among such girls. Expression of feelings and admiration, both in word and gesture, may be too highly wrought, and the head may be often extended. Too much attention is excited by their own personal appearance, and that of other people; there is a want of control over words and actions, and too few signs of mental action. The tendency to hysteria may be inherited, its signs may be imitated, there is predisposition in weak and nervous girls. *Its imitation.* This brain condition appears to consist essentially in too great a governance of mental states by impressions from other parts of the body, rather than by sights and sounds from without. Early detection of this tendency is important, that you may check its growth. *Management.* Avoid exhaustion, as from late hours; physical exercise and early rising are to be recommended; check any asymmetry or bad postures. If possible, secure many interests, many sources of outward impressions for the child, teaching her to think much of others, and but little about herself.

Introspection. We pass on from child-faults to certain mental states, which should be carefully looked for in young people. The term introspection is used to imply the habit in a child of thinking about his own thoughts—his own thoughts being the subject of his contemplation, rather than thoughts stimulated from outside. This introspection, as a brain process, is very exhausting, particularly when practised on retiring to rest in a half dormant state. Serious thinking about the mental state, goodness and badness, should, I think, be undertaken with the best mental faculties, and under guidance of a trained mind, and should always be followed by some action. Introspection is a form of self-impressionability, and owing to a want of impressionability from without. If this mental state often occur when we cannot impress the child, give him some fixed thought which he may learn to call up when his thoughts wander, as they often do, in trying to fall asleep; let him use his imagination, and call up some pleasant landscape scene, the sight of Mother, etc. Muscular activity during the day tends to check the habit. This mental habit should be looked for in children with brain exhaustion, it may result from exhaustion, or may produce it. Some children are weakly, and must lie down and rest through the day; find out if the thoughts run wild, if so control them by reading aloud some simple and familiar story, and thus control the thoughts.

Absent-minded children. Absent-mindedness, or a "brown study." You may sometimes see a child immoveable, apparently unimpressed by all around him, the eyes fixed with a stare. You conclude he was not thinking, for no expression of his thoughts can be got from him. Such habits ought to be checked.

Fixed mental impressions are important, some you

may desire to build up, others you will desire to remove. The first thing is to discover their existence—a fixed, or oft-repeated facial expression not in harmony with circumstances, may accompany a fixed thought, e.g. the expression of mental anxiety may accompany illusions. Blushing, not due to such external impressions as ordinarily produce it, may be due to a fixed thought. Find out the source of the fixed thought, that produced it; it may be some object seen which caused a fright; epilepsy may follow from fright, and the oft-repeated imagination, or calling back to view the frightful sight, or the mental impression it produced, may do much harm. *Fixed mental impressions.*

Illusions are not uncommon among children and adults who have perfectly sound brains. The child may over and over again see an ugly man or woman, a dog or a wolf; such illusions may cause secret fear, or they may not annoy him. Get the child to confess its illusions, explain that they are only dreams, do not speak of them, but do not avoid them; look in the child's rooms for any object that may suggest the illusion to him. *Illusions.*

Memory is an important faculty to cultivate, but it is not as valuable as the faculty of thinking. Memory, as a physical function of the brain, is due to its retentiveness of impressions received, and if carried too far, may lead to so many 'ties', or unions among nerve-centres, as to limit the number of 'free centres' ready for further impressions. Strong leading thoughts, or fixed impressions (too ready to be easily brought into action) may be firmly remembered; they are useful like fixed moral principles, but too many of them cripple the spontaneous action which otherwise might lead to new thoughts, following from fresh impressions. *Memory.* *Fixed principles.*

The want of good memory, and forgetfulness, may be due to what has been described as inattention, or the action of some strong stimulus, external or intrinsic.

An object lesson.

Some of the subjects I have submitted for your consideration in these lectures, may suggest methods for use in mental training. Suppose an object lesson on botany; you want to use some piece of nature's work placed before the class, or better still, in the hands of each pupil, as a means of training in observing and in thinking, and as a means of teaching processes of thought, and extending the mental capacities of the pupils, together with the cultivation of accuracy of method;—that is the desire of every scientific teacher.

Observing and thinking differ.

Observing is not necessarily thinking, but I will not now discuss the physiology of each process. Observing is receiving new impressions; thinking is a series of acts of psychosis that may follow such impressions. Observation of an object may, or may not, lead to thinking; it depends much upon the teacher whether the object lesson shall teach thinking, or observing only. Impressions, produced by the sight of the specimen, may be followed after it is removed by thought; descriptions given by the pupil are expressions of thoughts and help to enlarge his vocabulary.

Teaching by sight and by words.

An important result of teaching by impressions made by the sight of objects is, that the results in the pupil are more exact than those produced by words—it is often more healthful to impress young people by things seen, than by the expression of our thoughts. I have found such methods of observing and thinking, as are used in Chapter I., very useful in teaching a class to think, taking care to use examples enlarging and limiting the field of observation and thought, and showing the results of prolonging the duration of observation; thus—limitation of field of

observation to cells of radicle of pea, and to individual tentacles of leaf of Drosera. I would also examine the natural phenomena, described as to their antecedents and sequents, and the further outcomes of the sequency. I believe that logical processes of thinking may thus be taught to very young children. *Logic taught in object lessons.*

In teaching from natural objects, it is possible to insist on the discrimination between terms implying what can be seen, and what cannot. For the purposes of science, all descriptions should be given in terms connoting what can be seen. Scientific explanations should not assume an unseen and immeasurable thing, as a cause of physical facts seen and observed. We should, I think, be less anxious to dogmatise as to 'causes', more careful to distinguish antecedents and sequents; punctilious in distinguishing observations from inferences, and scrupulous in avoiding the assumption that any physical act is the outcome of anything but previous physical action. *The seen and the unseen.*

Mental states are probably due to the action of previous impressions, received by the brain in earlier life, or through inheritance,—the processes of education —lessons and play, example and precept—are in part the forces building up the mental structure. The possible inheritance of a tendency to certain mental states is most important in education. Children often have a tendency to the same conditions of growth, and the same mental faults, as existed in one or both of the parents; they may also inherit excellencies. Such faults of early life, the parent may have conquered in himself, and his struggles may lead him to think too seriously of that particular fault in his son—and too much of that fault only, instead of trying to develope the whole character—physical and mental energy. To understand the *Mental states.* *Parent and child.*

Inheritance of headache. child, study the parents—a strong predisposition to the early development of headache in children, is usual when one or both parents have much suffered thus—look for exhaustion and headache in such children.

Cultivate precision. We wish to exercise all the powers of all parts of the brain, thus, you cultivate the capacity for action of small separate parts of the brain—action of the exact brain-centre called for; (precision of movements)—action of corresponding brain-centres on the two sides (symmetrical movements)—such action being produced by stimulation through eye and ear. Cultivate the faculty of imitation in the pupil, by making him do as you do, calling into action the same centres in him as you yourself employ. Cultivate regulation of ratios and quantity of action, as affecting grace and fitness of movement, the tone and regulation of the voice.

Drilling lessons. Drilling lessons have often been looked upon only as means of "getting up the muscles", and they have been used accordingly, with the result that, as in the case of athletics, the maximum of good has not always been attained, and harm has sometimes resulted. *Physiology of calisthenics.* A few words as to the physiology of calisthenics may not be out of place here. When a muscle, that is duly supplied with blood, is stimulated to action, and work is accomplished by the muscular contraction, then the muscle grows. The nerve-centres are affected at the same time by the exercise, those that are caused to act in union, have those unions confirmed, and tend to act on future occasions with more exactness, and more quickly in similar stimulation. If the object of the physical exercise of the class be to drill the nerve-centres, increasing the quickness and precision of their action, then the brain-centre should, as far as possible, be free to receive the word of command, we must get the attention of the

class, and try to perfect the time of their actions, rather than to cause strong stimulation of the muscles. Leave *Free exercises.* the muscles free, have nothing in the hands, when you wish mainly to deal with the nerve-centres—use no clubs or weights, and let the hands be open. Arrange your exercises so as to produce movements in some definite order, at the same time, let them effect but little mechanical work; let the movements, following your word *Series of movements.* of command, be such as to exercise all the known physiological groups of muscular actions, the groups of muscles supplied by each cranial nerve, the eyes, face, tongue, head and spine. In the limbs, exercise movements of the large parts and small parts, and movements of the separate digits in flexion and extension, as well as in lateral movements. Each group of muscular actions, due to the energy of a brain-centre, may be brought into action by drilling.

Some very beautiful exercises with balls have been used, which tend, not only to regulate and quicken the effect of sight upon movement, but also to increase the power of accommodating vision as the eye follows the ball. I think that this subject of drilling the nerve centres is well worthy of more serious attention than it has received.

The child's mental processes may be too slow and *Quickness of movement.* limited in number, then try, not only to quicken these, but also to quicken the capacity of the brain for all movements, and interaction of the ear, the eye, and the hand, as in games.

Some children use too limited a vocabulary; perhaps *A limited vocabulary.* this is best extended by talking to and with the child, we must not wait for him to get his words from books. With deaf children, the oral method of teaching, when used alone in early life is often unsatisfactory, it does

not give a vocabulary sufficiently early for the development of mind action. Calisthenics are but one method of working the nerve-centres. It seems probable that the finer actions of the brain, in producing thoughts, may be well trained by seeing good works of art; form is probably more effectual for this purpose than shading and colour. I should like to see casts of statuary in all schools.

Care of children of defective development.

Exceptional children.

The care and training of children, whose conditions of development are not quite up to the average, is a very responsible duty. I do not refer to the care of the imbecile, and distinctly feeble-minded children, but of boys and girls distinctly below the average of their social class in make and in brain-power, children who will grow up to be men and women tending to failure, unless all their powers be drawn out, and they themselves protected from the more difficult paths of life. We have no definite facts upon which to found a standard of mental faculty, but I think that probably more than 5 per cent. of our school children are under class in some points of their development and brain-power. Such children should be known early to the educator, and specially studied and cared for. How can the teacher know from his observations, who in his school are the children below standard? A parent or master may say, is this boy well developed, healthy, and strong, and is his nerve-system at the present time in a good condition? The signs of defective development are of two kinds; (1) form, shape, proportions and structure of the parts of the body; (2) motor signs and visible conditions, such as were described in Lectures IV. and V. *The height,* weight, and proportions of the body may be

How to recognize them.

observed by actual measurement, or by a general view of the head, face, trunk and limbs. Mr Francis Galton, F.R.S. and Mr C. Roberts, F.R.C.S. have given us much useful information on this subject. The complexion, both the fixed colour due to pigmentation, and the varying colour due to the amount of blood in the skin, are noteworthy; blushing is an important sign of the action of the nerve-system.

Observation of a child. It is necessary to look at the body, as well as to the postures and movements, from two points of view; get a full face and a profile view. The head and the mobile features of the face may be first noted—the size of the head, its circumference, height of the vertex above the ears, the position of the greatest transverse diameter, also whether the head be round or long in shape. Other points are the width and height of the forehead; the facial angle; the position of the cheek bones; the lower jaw, whether it be small and narrow, or large and heavy; the ears, whether they be well shapen and symmetrical. The structure, as well as the colour of the skin, and the colour and kind of hair are also worthy of description. The significance of these signs in part depends upon the observed frequency of coincidence of defects in these parts, when the brain is slightly defective in its construction. The general signs of nutrition are, plumpness of the face and limbs, the eyes not being sunken, the skin being elastic, without flabbiness or dulness of its surface. *The body.*

If you think the signs of development defective, look to the postures and movements of the body, both those that appear to be spontaneous, and those that are stimulated through the senses. Awkward and frequently repeated movements, not the sequence of a direct impression, or not in harmony therewith, should be checked,

Signs of condition of nerve-system. such as clenching the fist, shrugging the shoulders, turning the head over one shoulder, and grimaces, etc. Biting other children is a low class habit, not uncommon among young children. Notice any incongruous association of movements, such as repeated frowning and grinning, taking care, of course, that such are not the result of a strong light on the eyes at the time, etc. Defects in the nerve-system, when there are defects in the make of the body, are often more difficult to overcome. In all these cases the moral sense should be carefully cultivated. A child with such weaknesses or defects as have been referred to, should not be deprived of the benefits of a good education; rather he needs it more than others to prevent his failure. If there be some defects of development, they are probably capable of improvement, and our energies should be stimulated to overcome the defect. A defect of muscle, or organ, or other part of the body, may often be improved by training that part or faculty, —always without fatigue. Brains actually grow under stimulation. Spontaneous action should be encouraged, by carefully feeding and stimulating the individual faculties of the brain through the senses; try and make the child impressionable to surrounding conditions by oft-repeated practice; when you get more spontaneity, then train it. Never let a feeble child get exhausted as the outcome of your training—this is never allowed in an asylum school for the feeble-minded. Remove fixed habits, such as uniform gestures oft repeated, not in harmony with the circumstance.

Defects to be remedied by education.

Improving the brain.

Dr Segwin. In the published *Proceedings of the Conference on Education under Healthy Conditions*, Manchester, 1885, page 218, Dr Shuttleworth says, "More than that, it had been proved by some observations of Dr Segwin, that absolute increase in the volume of the brain took place

when instruction had been imparted, simply through the medium of the senses and the muscles—as in training the eye and hand."

Stammering.

Stammering is often due to, or coincident with, some defects in the development of the nerve-system. When the boy stammers on commencing to speak, he almost immediately stops on uttering certain syllables or words, —he does not proceed in articulating because certain muscles are in a state of spasm. Stammering consists essentially of spasm in certain muscles, which prevents them from being freely acted on by the brain-centres—the range of the spasm, the number and groups of muscles affected, may vary in different cases. The spasm affects the face, especially the parts about the mouth, and may leave some permanent impress thereon, as marks upon the skin due to the oft-repeated recurring spasm—the mouth is partly open, the lower jaw slightly depressed and fixed—the tongue is seen near the tips of the lower teeth in tremor, the spasm of the tongue muscles may be felt below the lower jaw, and one muscle in the neck (Omo-hyoid) is sometimes in strong contraction.

Stammering imitated by those predisposed.

Management, to be effectual, must be long continued. Every prolonged attack of stammering tends to its recurrence. When the spasm commences, stop it—let the boy stop speaking, that will arrest the spasm—he may try again presently. Stammering may be imitated by other children, they should not be allowed to imitate it, especially brothers and sisters with similar inheritance. Let me describe a case to you.

A case of stammering.

A schoolboy, eleven years of age, was brought to me because he had been liable to stammering for the last four years; this trouble having been increased during the last three weeks, coincident with digestive

trouble. On asking him a simple question, he stammered in his reply. Looking in his face, the following conditions were seen. In the frontal region, spasm of the muscles produced both horizontal and vertical furrows; in the lower part of the face, the mouth was widened on either side, together with elevation of the upper lip, opposite the canine tooth,—this was more marked on the right side than on the left.

Defective children. Let me make a few general remarks on defective children. When seen in any exercise, there is apt to be unequal movement on the two sides of the body. In the face there is apt to be much frowning, and occasionally vertical furrows, owing to contraction of the eyebrows, not corresponding to the impression of any special stimulus. Such children are usually under the normal weight. A curious habit, often seen among the feeble-minded, is as follows:—if *A* hits *B*, *B* will hit *C*, not *A*. *C* hits *D*, and *D* breaks the window. Among the feeble-minded, when well cared for, exhaustion is rarely seen, but is carefully watched for.

Eyesight. Conditions of eyesight in school children are very important; it is specially necessary that short sight should be early detected; if not cared for, it tends to increase, and endangers the health of the eyes. Examination of the eyesight may be easily conducted in school. Let the set of test type be hung in a good light, each child in turn may be made to toe a line 20 feet from the type, those who cannot read the letters distinctly have some defect, which should be further investigated.

The acquisition of knowledge should always have some practical aim; we may ask ourselves how may the study of children lead to better care of them? I think some hints as to methods of management have been

given; to give further point to what I think ought to be done, at the same time avoiding reference to the work of individual groups of teachers, I will in these concluding remarks refer to Public elementary schools only. *Why should we study the children?*

It will be granted that the educational processes should be adapted to the children, and it must be admitted that the average methods must be adapted to the average child. Are the average methods of education adapted to all children? A while ago it was found out that the deaf and the blind could not be taught in ordinary schoolrooms; these are now in part provided for by small special classes. I desire to draw attention to another class—the nervous, irritable children; children who are irregular in attendance on account of headaches, recurrent chorea, occasional fits; habitual truants, whose brain defect can be proven; the child so dull that it remains among the infants and learns nothing. As a hospital physician, I meet with many such children[1], though doubtless they are but a small percentage of the school population, and from what I see, I think these are practically not educated[2]. *Educational problems.* *Recognition of exceptional children.*

Is this to the public advantage? Why are the deaf and blind educated? A part of the reason is that they may not become paupers. Why are the children of slight brain defect uneducated—children tending to become passionate, to pick up bad habits and practise them, tending to criminality, or, if too feeble for that, to pauperism? They are not neglected intentionally, but because they are not known to the school managers, it is nobody's business to find them out; they are not classified, and take their chance with the rest. Now my *Their educational neglect.*

[1] See Table at the end of Chapter VIII.

[2] *Report of Royal Commission on Blind and Exceptional* Children.

argument is, we can discover such children, and pick them out by definite physical signs; we can pick out from a class, the child not up to the average, the child tending to failure from want of brain-power.

Early recognition important. To say that such children are few in every school is no reason for their neglect; we rejoice that but few have such inborn conditions as make them tend to social failure, pauperism or crime, but we wish that none should thus fail. Let such tendencies be detected early, and pointed out to the educationalist, that he may tend such cases carefully, helping to correct the defects due to brain condition.

The cruelty of neglect. Neglect in these matters does lead to unintentional cruelty to children, and to what I think more important, to the educational neglect of wrong-brained children. The teachers do not want to neglect them; such neglect is due to ignorance, for which the managers are responsible. Now, as to these wrong-brained children, they are worth helping; in most cases a genius is abnormal; the very faults and nervousness may be trained to become admirable qualities—sensitiveness of mind, nobility of mind; and the fidgety child may become an active man. Such children too often escape from an educational process unsuited to them, but still, better than no education.

Weak children who turn out well. The nervous, excitable boy, always ill with sick headaches while at school, is excused from school attendance; at home he is idle; too often the parents are neglectful and unwise; and as he grows up, when drink or passion inflame him, he commits some act bringing him within the power of the police. I have seen the education of many such continued with success when removed from large schools, and placed at inferior, but small and quiet schools. Again, the weak-brained, feeble-minded child *often* gets so teased, that at last he cannot be induced

to go to school; his attendance is excused on the ground of health. What becomes of him after that?

Medical inspection of schools.

This raises the question whether the ordinary school manager is able unassisted to discover the brain condition of the children. Should there be an occasional medical inspection to aid the managers to determine how they may help on the development of the children? This might be met by occasional medical inspection, say once in the year. We are not speaking of questions of hygiene, or cases of illness. At the inspection, an experienced doctor, looking over the school class by class, would soon select those probably requiring some special care; the teachers would present for examination any child they found specially troublesome, often complaining, short-sighted, very passionate, etc.; and the cases of children excused from attendance on grounds of health would be considered; advice might be given on all cases.

At a school I recently visited, a child was presented by the teachers as 'not dull but somehow wrong'; grave brain defect was obvious; the advice given was to keep the child, if possible, at school and out of the gutters.

A boy was brought to me who was frequently absent, and often punished when in school; he had a hare-lip, a defect of the heart, and an ill-developed brain. He has a right to be educated, and ought not to be punished for dulness of brain.

Training the brain to bear strains.

As to training the brain to stand strains, I believe it is better for the nervous child to be educated. He must meet the shocks and strains of life, and if properly educated and exercised, he will bear those shocks and strains better than if untrained to think and exercise self-control.

What can be done for these children? A want is

Auxiliary classes needed. pointed out, and we are prepared to show how this special class of children may be classified, and in individual cases, or a group of cases, we can say what will aid brain development[1].

In classes for the dumb, I have seen cases very defective in brain being educated. In the highest class in Darenth Schools I have seen feeble-minded children being educated and sent out into the world. Small classes and special teachers could well manage the dull, the excitable, the wrongly-made children.

As to the expense of teaching a few children in a small class room, instead of in a large room, would not the money be well spent in an effort to lessen crime, pauperism, and social failure? Should the endeavour be made to educate and save the child, or to reform the drunkard and criminal, and redeem the pauper to society?

I should like to see a tentative effort made. Provide inspection for a few large schools, and two small class-rooms with suitable teachers, and the truth of these statements would, I think, be soon demonstrated, and the value of classifying the brain-power of the children would be recognised. The school examiner classifies by

A public danger. intellectual functions only. Every weakly or troublesome child who now escapes from public education is a failure of the system, and every such child is likely to be a public harm.

[1] See Memorandum by Dr G. Shuttleworth in *Report on Children in Schools.*

CHAPTER VII.

THE SIGNS OF MENTAL ACTION, THEIR OBSERVATION, SIGNIFICANCE AND MANAGEMENT.

Visible signs of mental states.

IN former lectures I have spoken of the signs that you may observe as indications of the physical condition, and the brain state of a child, many points in physiognomy have been described as indicative of the child's development, and various movements and postures of the body have been given as signs of the condition of the nerve-system. I must now direct your attention specially to such actions as indicate the mental state and functions of the brain.

All mental action expressed by movement.

As stated in former lectures, all visible expression of mental states, and mental action, is by movement and results of movement; it may be useful to give examples of such mental signs as may be observed in school children. We have now to describe special series of movements, and their relations to surrounding objects, and actions in other people.

As a means of giving a practical bearing to my remarks, and to encourage your own observations, I do not propose entirely to dissociate action in the body of a mental kind from that effecting other purposes. It will be found that this association of the two kinds of action is useful in considering the practical questions of management; it will be shown that when the child's

Mental state regulated by action. habits are too little varied in mental acts it is well to cultivate more varied general action, as in the movements induced by cricket and other games of skill, whereas when mental action is too vague and various, when spontaneous thoughts wander vaguely, and are not readily coordinated by circumstances, it is useful to render the movements in play and exercise more uniform, i.e. less exciting. We may thus discover the principles by which we may judge what employments are likely to prove exciting. Of course in each case the practical outcome of your management must be observed, still, it is useful to form your plans of action upon some definite principles, and to know what facts to observe and how to judge of their relative value.

Classes of movements. There are four great classes of movements considered in relation to the time of action of the visible parts of the body. (1) Uniform series. (2) Augmenting series. (3) Diminishing series. (4) Action adapted by circumstances; each of these modes of action will demand our separate consideration.

Uniform series of acts. *A Uniform series of actions* is seen when the individual does the same things over and over again. Walking is a uniform series of acts, and is an example of the kind of action often called "automatic," for walking may occur almost without any stimulation through the senses, at any rate without such stimulation as produces "conscious impressions". One reason why walking is not necessarily an intelligent act is because it is a uniform series of acts, i.e. a repetitive action, and it may occur without much control through the senses, a deaf man may walk in darkness, walking may occur to a great *Walking.* extent independently of external impressions. Walking and talking are two series of acts that may occur in an individual at the same time, the former may be a uni-

form series while the latter is much varied. For children, walking may be varied by running and playing. To vary the more mechanical action, may lessen the amount of spontaneous thinking at the time, and lead to recreation of the mental faculties. Similar characters may be found in manipulative processes used as a means of training. In sloyd work making a peg uniform on every side is rightly placed early in the course, because it involves a uniform series of acts in cutting the wood equally on every side. To perform an action with exact uniformity is a result of training, and is a great advance upon the child's natural spontaneous action very akin in its nature to mental action. To make a wooden spoon is not to perform a uniform series of acts. Dancing is a less uniform action than walking. The game with a ball that a child plays by himself is a more uniform series of acts than cricket. In some people conversation is very uniform and slightly varied, and the vocabulary very limited. Some of the awkward "habits" of children are the repetition of uniform acts, such as lateral movements of the head, grinning, shrugging of the shoulders, frowning, putting the fingers in the mouth, etc., such uniformly repeated actions being apparently spontaneous, and not readily controlled by impressions from without, are not adapted to the social circumstances. In teaching young children in a sloyd class it seems necessary to cultivate uniform and often repeated actions, which thus become more exact and uniform, a good training is thus effected, their spontaneous action is thus brought under control by what is said to them and by the sight and touch of objects, this is a useful kind of training. With children the endeavour of the teacher must always be to regulate their action through the senses; children are full of spon-

Uniform action.

Sloyd work.

Uniformity and spontaneity.

Cricket.

"Habits."

Spontaneous action rendered uniform. taneous movement, it is easier to coordinate these at first to a few uniform actions than to the many complex acts which constitute mental expression.

Uniformity of a series of acts, or the frequent repetition of an act, is often useful. An action often repeated may become more exact, i.e. it is not quite uniform but becomes more like the copy each time it is repeated. Uniformity is antithetical to spontaneity and to augmentation of a series of acts.

Uniform action taught. Uniform series of movements may at first have to be produced in the child by impressions from without, i.e. they must be taught, they may then be said to be conscious movements, or voluntary, as in the child who is being taught to walk, to speak, or to make a wooden peg, later, after frequent repetition, they are said to become automatic because they occur upon less external impression. You may make such automatic action again "conscious or voluntary"—break the uniformity of the action, make the child jump or run; probably thinking may be similarly automatic. The method of making a uniform unconscious line of action again voluntary is by producing some impression upon the individual, the consciousness seems to correspond to the construction of some (diatactic) new arrangement among the nerve-cells getting them ready for some new mode of action. Either walking, playing a game, or talking may become too uniform. On the other hand we often need to remove or to reduce the consciousness of action in a certain direction, this may be effected by frequent repetition under the least possible stimulus. Social manners are rendered more exact, and such action becomes more uniform, and less conscious, by frequent repetition, so that finally the action does not interfere with thinking on other matters.

Increase and decrease of consciousness.

Uniform series of acts, whether mental or motor, are the outcome of action in comparatively few brain-cells, but these nerve-cells perform more work than when the acts done are more varied in their series. In trying to remove some uniform action or fixed habit, note what stimulation produces it, whether it occurs without any stimulation, or upon every stimulation, as is sometimes the case; it is also well to try what action may most easily be substituted for that which we wish to remove. This subject will be referred to again further on. Among uniform acts of an objectionable kind we may include the frequent use of slang words. *Uniform mental acts.*

I have seen a little boy five years old, standing before me in a Kindergarten, with a narrow forehead, mouth open, teeth grinding, face dull and expressionless, with creases on his forehead from irregular muscular action and frowning, his eyes directed towards me, but constantly moving irregularly; he was thin and of slightly defective make. When spoken to these irregular movements ceased, and his facial expression was good. When he sat down to his paper-folding, he worked away readily. Teacher said "he was dreamy, and did not work well". There is great hope of improvement for such a child, for his irregular action can be controlled; suitable training may make a good man of such a boy, and the teacher is cultivating his power of attention to Kindergarten work. *A dreamy boy in Kindergarten.*

To replace a uniform action, is to cause a new line of action. The conditions under which a new line of action is most readily brought about are, where the nerve-centres are well nourished but stimulated to the least possible amount through the senses—the brain is thus left free and unoccupied. Previous training, i.e. previous impressions, make the brain more apt for *A new line of action.*

new brain action. A well-exercised brain is more apt to receive new impressions and produce new lines of action. It must be remembered that mental action may produce mental fatigue and inaptness for further mental action without signs of bodily fatigue.

The spread of action.

An augmenting series of actions is seen in the spreading of the area of visible action; this may be seen in the youngest children in the act of crying. The sound of a sharp word spoken to a child may be followed by depression of the angles of the mouth, alternate opening

Crying.

and closing of the eyelids; altered respiratory movements causing screaming, flushing of the face, and, finally, action spreading to all parts of the body, the boy cries, stamps, the fists are clenched and he hits out. This augmenting series of acts is produced by an increasing area of brain in action—no wonder that such a storm among the nerve-cells is followed by the signs of exhaustion. Such series of movements may occur, sequential to some stimulus, the final movement being much stronger than would be expected from the force of the primary stimulus, each group of acts as the series progresses increasing in number and in force. It is the spreading area of movements, or the augmenting number of parts moving, as the action proceeds, that is here specially indicated, such action being started by a slight stimulus while the force expended is very great. In the act of crying, and in many instances of augmenting action in adults, such signs are considered as expressions of emotion or mental

Diffused brain action.

action. It appears that a nerve-centre in the brain may be excited by a stimulus from an organ of sense, and may then discharge its efferent force to more than one nerve-centre, so that the nerve-currents become reinforced or strengthened as they proceed finally to the muscles which produce visible movements. Such rein-

forcements of action are seen in the youngest children. In yawning and in laughter we see an augmenting series of actions; all such are apt to be started off by imitation; we here see a reason for not allowing too many pupils of the same type, whether fatigued, nervous or ill-developed children to be congregated together.

Yawning. Laughter.

The march of visible action as seen in the child, or the order of the increasing area of movement, needs to be observed. Is it from the larger parts to small ones, as in shrugging of the shoulders, or when the lower part of the spine is bent forwards, the head drooped, with subsequent movement of the hands, fingers, the eyes and facial muscles? Do the movements begin in the small parts about the face, and afterwards pass to larger parts, as in crying? To turn the eyes to another person, uncover the canine teeth, set the mouth firmly, double the fist, plant the feet and hit out from the shoulder, is to bring parts of the body of increasing size into play; to turn eyes and head away from the person previously seen, say some words and go through the movements described as crying, is to produce an increasing area of movement, passing from large parts to the action of small parts.

Spread of action from shoulders to eyes &c.

Fit of passion.

A storm subsiding.

In the cases given the area of action may spread as the outcome of some present impression produced from without, in other cases it is due to the return of the natural spontaneous action of the brain-centres. In the child let out from school the crowd of movements seen results from the resumption of natural activity uncontrolled; the same thing probably occurs when fatigue leads to fidgetiness and playfulness. The signs of the rising storm after a sharp word form a very different kind of augmenting action, and call for a different mode of management. It is not uncommon to find that with an

Increasing movement from impression or spontaneity.

Augmentation in area and quickness. augmenting area of movement the time of action quickens; this is seen in conditions of mental excitement. Stammering is an augmenting area of movement that has been described.

Diminishing action. *A diminishing series of actions* is seen in a child, when after activity he quiets down, fewer and fewer parts of the body being seen in movement. This may be seen in the quelling of the rising storm, or in the subsidence of all action; it may indicate an intelligent state, or approaching somnolence. When the signs of emotion *Quelling emotion.* are subsiding the larger parts of the body become quiet first; the eyes, face and fingers move after the larger parts of the body are at rest. Acting upon this suggestion, cause some fresh action of these larger movements, it will relieve his feelings to hit out, to run round the room or catch a ball. A good laugh, as being a series of acts commencing with small muscles, may completely change the previous mode of brain action and remove the display of emotion.

Usefulness of diminished action. To lessen the visible action, or to diminish the number of parts in action, is to save strength and save wear in the brain—stop the storm of stammering, the explosion of passion, the violent cry or the hysterical convulsion. You can watch the effect of what you say and do to the child and act accordingly. Stillness and quietness of manner in the teacher often help to diminish visible action in the child; conversely, much action in the teacher is apt to be followed by over-action in the child. *Tone of commands.* Words of command intended to diminish action should be short, and uttered in a quiet, uniform tone. In some schools quietness is obtained by use of a bell or a whistle; Mr Galton has introduced a whistle which can produce a graduated series of sounds. The amount of brain action produced by teaching may be advantageously

reduced by lessening the stimulation; let there be only one stimulus, the sight of one thing, not many things at a time. So as to intellectual training, diffused and irregular mental action may result from simultaneous stimulation through the eye and ear: first shew an object to the class, point out its parts, then explain the names of these parts, and finally their uses, *i.e.* first impress the brain by sight, then by the sight and sound of the names of the parts, finally giving your further explanations. To commence with an explanation of the uses of the parts of the object may cause mental confusion, and the appearance of the signs of mental anxiety.

How to avoid mental confusion.

Action adapted by circumstances is a very high class manifestation. The action may end in something being done or something said which produces an impression, so that the outcome of that action is not lost.

Adapted action.

The most useful actions of this kind are such as usually occur in well-trained people under the circumstances. In a child untrained in social behaviour to see a friend during his walk is followed by "reinforcement of action," he looks uncomfortable, wriggles, shuffles, puts his hand to his cap, and looks away from his friend —the trained boy simply lifts his cap, a less action but one which is the social average under the circumstances. Such well-adapted action comes only by training, but is much more easily acquired when the ancestors have been similarly trained. The occurrence of much spontaneous action, and the tendency to "reinforcement of action" are antithetical to the occurrence of such actions as are simply adapted by the circumstances. To build up such adapted manners you must quell spontaneous action, and try and avoid producing any "reinforcement." Repetition will render the action more certain and exact under the stimulus. To acquire such modes of action

A friendly salutation.

indicates good cultivation of brain power; it gives not only good manners, it is a training in useful forms of mental expression.

Physical terms.

Terms or words which correspond to or may be impressed mentally by the sight of physical objects (physical terms) are more suitable for use in cultivation of young children than those which do not correspond to impressions made by objects. One of the chief means of improving the mental faculty of the brain is by impressing it frequently and variously through the senses. In this the brain appears to be like a piece of iron, the better for the number of impressions made upon it. The more often a healthy brain is variously impressed by circumstances, the more does it become controllable by circumstances, and the more is the mental action in harmony with the environment. It must be remembered that the results of impressions may be inherited. In estimating your power to govern a child, note what actions are most easily controlled, and exactly what movements are engaged in such actions. When the inherited tendencies to action are not good it is the more necessary to take special care that bad impressions should be avoided—in the case of a boy with some tendency to habits of vulgarity avoid the impressions he may receive in a 3rd class railway carriage and in the stables more than in the case of a child of natural refinement.

Inherited tendency.

Opposed mental states.

(*Antithetical or*) *opposed mental states* are such as do not commonly co-exist, but are capable of replacing one another. The mental states termed kind and unkind, defiance and shame, joy and pain may be called antithetical, as they do not commonly co-exist, the presence of the one mental state for the time precludes the other. The antithesis of the mental states joy and pain is expressed by the opposition of the signs which indicate

Antithesis of joy and pain.

these conditions. The antithesis of the mental states joy and pain might be anticipated by the student of the physical expression of these states, for the two modes of facial action cannot co-exist. This illustrates one reason why the student of mental science should observe the expression of mental states as seen in visible action of the parts of the body. Hands cannot at the same time be both motionless and full of movement; now in the mental state called attention the hands are still, in the fidgety child the fingers present numerous spontaneous movements; these physical signs are opposed to one another, as are the mental states corresponding. Those motions whose physical expressions are antithetical are the most unlikely to occur together, or if they do coincide momentarily there is a conflict seen in the body between the two physical states, as in an individual who while suffering pain still tries to look happy, and soon one or other condition gains the ascendancy. This principle of antithesis is very useful in trying to gain knowledge as to the causation of mental states, and may serve to guide practice in education; you may know what states of mental action are antithetical by observing their opposite modes of expression. It is useless to try and reconcile mental states naturally opposed, but it is most useful to replace one by the other; a mental state may often be best removed by raising its antithesis, defiance may be replaced by shame, fear by the signs of joy. In trying to produce an opposite condition of mind to that found at the moment, the free or unused parts of the brain must be acted on rather than those which are at the moment acting strongly in expressing some emotion or the mental state you desire to replace. If the child shows signs of anger, and you do the same, that makes him worse. Sight of your

Attention and fidgetiness.

Use of the principle of antithesis.

Storm of passion. actions expressing anger stimulates the corresponding brain centres in the child to further action "by imitation": show the child a pleasant quiet face, the sight of your open hand may act upon the parts of the brain he is not using, and may be followed by the removal of his frowns and snarls, and the relaxation of his fists. If you can thus stimulate in the boy those brain-centres which you use in your own brain, and which were unused by him, you will effect a good purpose and may prevent the recurrence of a rising storm. It is important that you should note the order of subsidence of a storm of movement, so as to know how to deal with it another time; those movements which first subside are those you should endeavour to control. When dealing with an *Quelling anger.* angry child remove the signs of anger first, then the brain will be more impressionable to the finer effects of the influence of your voice. To try and alter the mental state by thus altering the attitudes expressing mental action, is not to act upon the child in a merely mechanical way; the actual mental state usually corresponds to the external expression, the two kinds of action cannot long be different from one another. To get the child to *Pretending to sleep.* sleep, induce him to pretend to be asleep, the genuine condition may soon follow. To require respectful behaviour and formalities is likewise useful; so the feeling of reverence does not coincide with irreverent words and action.

Opposed mental states. A knowledge of opposed mental states may be useful in the correction of faults.

Substitution of mental states. For a child whose spontaneous movement is not easily controlled do not make him sit still as a punishment, that demonstrates to him the pain of subdued action; try and show the pleasure of keeping still while some object of interest or interesting story is before

him; that is, substitute some mental action for his spontaneity.

Mental dulness.

For the child too dull in all mental action, encourage spontaneous action by letting him stand, move, interrupt you or gesticulate during the interesting lesson or the story telling. As he has too little brain action do not lessen it at any time, and let his games be considered matters of importance.

Concerning the removal of thoughts and modes of action and the change of a line of thought.

Removing a thought.

In many cases where it is desirable to remove a thought, or a mode of thought or action, it is necessary to permit and encourage spontaneous action which is ever ready to recur in the young, healthy, and active brain. We may endeavour to raise to activity a line of action previously impressed in a permanent form—change the occupation and the external impressions. In this matter we see the permanent value of a well-stored mind, fixed mental principle and belief, and for the child the value of the memory of a happy home and joyful holidays; this may perhaps be called employing the memory and the imagination.

Value of laughter.

It may be taken as a rule that to remove a previous or existing impression in the brain, whether it be for thought or action, care must be taken to avoid strengthening the impression, as by punishment, and if possible by rebuke, call up spontaneous action, or produce a general reinforcement, as by laughter, &c.

Quelling thought.

Quelling certain thoughts may follow new impressions produced from without. Thoughts may arise from impressions produced by any part of the body upon the brain; these may be removed or quelled by impressions produced from without. When a strong attempt is made to quell a certain mode of mental action, in place of

substituting another kind of action, it is not uncommon to have a great augmentation of action subsequently, and a crowd of uncontrolled thoughts, not expressed in words, but indicated by facial and other modes of expression, in the form of obstinacy, sullenness, flushing of the face, clenching or grinding the teeth, &c. The least amount of stimulus from teacher that will attain a good end the better. A sharp word, or an angry look, may produce one of two results, it may stop all brain action, and thus render the child stupid; it may stimulate a great many nerve-centres in the brain to irregular action, a storm of action may occur, the angles of the mouth being depressed, the face flushed (now is the time to stop the storm), the eye-lids screwed together, the forehead crumpled, the head bent, fingers clenched, fists put to the eyes &c. (cerebral reinforcement). The word of command is a very important form of stimulus to the child's brain, the least force in it that will effect the purpose the better; a gesture may be better than a word, the fewer words the better, a simple quiet word may produce the co-ordinated action, many words may produce too much diffused action. Watch the effect of the command in each child and act accordingly. Both eating and sleep may help to remove mental impressions, but see that the sleep is sound and undisturbed.

Effect of rebuke.

Crying.

Spontaneous thoughts.

Spontaneous, uncontrolled or wandering thoughts (Micropsychosis) frequently occur both in the children and in adults, as we know by recording their expression. The expression of spontaneous thoughts uncontrolled by circumstances is seen as soon as the child commences to use words. This spontaneous occurrence of thoughts not in harmony with circumstances is very commonly seen concurrently with spontaneous or irregular and uncontrolled movements. In young children their chatter

is unsequential, and their movement in excess of the work done; nervous children have excessive movement and much vague thought. In adults fatigue often leads to wandering, irrational thinking, and may be accompanied by restless movements; this is seen in excess in delirium.

Thoughts and movements.

As rough analogies: a child is fidgety (full of uncontrolled movements) and is inattentive (uncontrolled thoughts); during sleep, impressionability is lessened and dreams are spontaneous. Nervous children are full of spontaneous movements, and often have many strange, disconnected, imaginative, precocious thoughts. In adult life there are wandering, unbidden, wild, ungoverned thoughts; a mass of thoughts, a cloud or a rush of thoughts through the brain. In healthy people these are best controlled by things seen and heard. This process of irregular thinking is fatiguing, and may lead to exhaustion, with inability to think correctly and quickly. Muscular exercise is then useful in such cases by changing the mode of brain action. We do not see any action in the child worthy of being called "thought," till we see in its movements the signs of coordinated action.

Observe effects of school methods.

It is most important in the practical work of Education to observe what methods of dealing with a pupil—what modes of impression—most readily call forth a mental response. The least display of force on the part of the teacher that will effect the purpose the better; a gesture may do better than a word; the fewer words the better; a simple quiet word may produce good mental action, whereas many words may produce too much diffused mental action. Watch the effect of the command on each child, and act accordingly. The principal means of controlling mental action in the brain are sight, sound, touch—their relative value varies much in different children. To train by use of books, black-boards and pictures

Eye and Ear. as well as by most means of demonstration is to cultivate the brain through the eye. Verbal instruction is received through the ear.

Touch. In speaking of *Touch* as a means of cultivating mental action as a lower mode than through eye and ear I have no wish to depreciate its value—on the contrary, cultivation of mental action by touch may be carried to great perfection, as is shown by the case of children deaf and blind. Further, if it be a mode of culture that is practicable, on that ground alone it ought not to be neglected. In some games, in industrial processes, and particularly in Sloyd, we have a systematised method of mental culture by the touch. In manipulative processes the brain is controlled by the tool, as well as by the eye which looks at the model. To write a sentence impresses it upon the memory, not only by seeing it in written words, but also by the movement of the pen which reacts on the brain that moves it.

Arrangement of classes. In concluding this lecture I propose to refer to some points in school management such as have suggested themselves to me during my observations of children seen in their classes and at work. Very different methods of arrangement of pupils in classes may be seen; sometimes there appears to be no attempt made by the management to place the children upon any principle, all are looked upon as much the same. The few children most defective in development are often placed together well within view of the teacher, thus they are less likely to do harm. If left alone the nervous children usually tend to congregate in the back rows; they are usually quick mentally, and their work may be up to time, even if they have been playing; it might be better to recognise and scatter these children. The advantages of the interaction of children upon one another are so great that it seems

Nervous children gregarious.

well that they should not always work in the same groups. In doing work from the black-board, short-sighted children should be placed where they can see properly. *Short sight.* Children often differ greatly as to their receptiveness through eye and ear; I have been assured that some children may take down dictation correctly from a passage read aloud who cannot copy from a book without mistakes; such facts may suggest arrangement of class work. The lighting of school-rooms is not always convenient, some children may be seen constantly frowning from the effects of too strong a light. The form is sometimes so close to the desk that the child cannot stand up in his place without bending the lower part of the back unduly (lordosis). *Lordosis.* It is usual to see children when standing in class and answering questions hold up one hand as a sign of readiness; in the case of children with nerve-weakness this holding out of one arm produces lateral bending of the spine.

CHAPTER VIII.

THE SCHOOL. CLASSIFICATION OF CHILDREN. SCHOOL REPORTS.

A perfect child.

THE perfect child, from the physiologist's point of view, must have a good inheritance through both parents, a body not only sound in all its organs and structures, but this must also be accompanied by mental functions appropriate to his age. The body must be well proportioned and of the normal height and weight, the features well shapen, distinctly cut and symmetrical, such as experience shows them to be in the best made individuals; the colour must be good and the signs of nutrition evident. The healthful signs of the condition of the nerve-system are seen in its spontaneous action and in its impressionability, and also in response to external stimulation such as is appropriate to the age of the child. The rhythm of sleep, waking, appetite for food, aptitude for play and work, being such as are found in the best average of our children at large of the same age. Further, observation will show symmetry of action in those movements which are ordinarily symmetrical, as in facial expression and walking, the individual movements being correct in time; and in quantity.

Nerve system.

Symmetry of action.

There may of course be many types of perfect childhood, and of good development of the body, just as *there are* innumerable types of good mental faculty.

The perfect child can then only be known as we see him in action; and his mental faculty is demonstrated only by mental tests. The average of children are not perfect in their organisation or their condition; those that approach the nearest to perfection of type still require education for their further development, and to fit them for social life. *The child in action.*

Education, properly conducted, commences with the earliest days of infancy, after a year or more the child becomes a member of the family circle, and the home community. As the special individuality of the child developes he usually requires, and demands, enlarged surroundings, more companions and a choice of associates, thus raising the necessity that he should become a member of some small school community. With increasing years the small circle again becomes irksome, because the probabilities are that the further development of the child meets with too little response among the limited number of associates. The boy then gladly passes to the larger school--and the young man to the University where he may meet the most varied minds, and mix in the society of men of high culture in special lines of thought and work. In entering on practical social life the man gradually forms his own surroundings till the circles of friends, acquaintances and social connections, are formed by the action of his fully developed character and habits. *Education.* *Enlarging interests.*

The Rev. A. R. Vardy, Head Master of King Edward's School, Birmingham, in a recent address to Teachers[1], said:—

"Mr J. G. Fitch lays it down that every true teacher 'wants to help his pupil to live a fuller, a richer, a more interesting and *Dr Fitch.*

[1] See paper read before the National Union of Elementary Teachers at Birmingham, 1889.

The teacher's ideal.

a more useful life. He wants so to train the scholar, that no one of his intellectual or moral resources shall be wasted. He looks on the complex organisation of a young child, and he seeks to bring all his faculties, not merely his memory and his capacity for obedience, but also his intelligence, his acquisitiveness, his imagination, his taste, his love of action, his love of truth, into the fullest vitality;

'That mind and soul according well,
May make one music.'

No meaner ideal than this ought to satisfy even the humblest who enters the teacher's profession.'

Observe that in all these descriptions of the teacher's ideal our attention is directed to the whole nature of our scholars, not to the intellect only, but to the physical and moral faculties also. The whole child is to be cared for, trained, fitted for life. No thoughtful and loving parent would be content to see his children growing up selfish, untruthful, dishonest, however vigorous their bodily health might be, however disciplined and stored their minds. He would not be content to see them incapable of mental exertion, unobservant, without judgment or reflection, even though their health was good and their moral character blameless. Nor would he be content to see them feeble in body, unable to use their physical powers, though the other parts of their nature were duly developed. What our ideal is for our own children must also be our ideal for the children of others whose education we undertake. Such an ideal may not, indeed, always be consciously present with us. As I have said before, there is much in our daily work to draw us down to lower levels, and other standards are constantly being set up for our guidance; but even amid the dull prose of actual school work there must be beating in our hearts the rhythm of this noble strain. The ideal must have taken possession of our souls, it must unconsciously leaven all our thoughts and actions; and when in the children before us we see tendencies, actions, and habits that contradict and thwart the ideal, we must feel that here is a call for our thought and work. How different this conception of the teacher's duty is from some conceptions which currently obtain I need hardly stay to point out. Some of these current opinions are little better than grotesque absurdities; that, for instance, which regards it as the aim of education to turn out in as short a time as possible a clever machine for making money.

But leaving these, it may be worth while to note some legitimate deductions from the nature of our ideal; deductions warning us against mistakes only too commonly made.

The importance of the physical well-being of our scholars is a subject which happily is now attracting much popular attention, and we may indulge the hope that the tide which has at last turned in that direction will continue to flow."

In this ideal of the teacher's work we have before us much to aim at. the difficulty is how to accomplish the ideal. I propose for your help the scientific study of children, especially as to their development and brain-power. Dr Fitch says the teacher should look upon the complex organisation of a child and seek to bring out all his faculties; to do this in a scientific manner we must observe children, know what to look for and how to describe accurately and exactly what we see, searching for the cause of every phenomenon noted.

Influence of children on one another.

Children exert much influence upon one another, usually for good, but it is not always so—the advantage of this interaction of the pupils is one reason why they should be encouraged to play in games, and seek each other's society out of school hours. Examples may be given where such influence is not for good, take an excitable child, whose excess of movement almost amounts to that seen in the condition termed Chorea.

Excitable children.

A second child, who has inherited the tendency to over-mobility of the nerve-system, is very likely to imitate the first and be influenced unfavourably by him. This specially applies to children of one family, who often tend to similar defects in action, owing to similar inheritance; a child who is over-mobile, one who stammers, or is hysterical, should not be in daily contact with its brothers and sisters only, but is benefited by mixing with other children differently constituted, whose action he then tends to imitate.

Slight defects in children.

I do not say that children with slight defects should not be admitted into the school, but that there should not be too large a proportion of them; they should probably not be in larger proportion than is found in general society. Again, it is not well in general schools to congregate in class, or in other associations, children with like defects. In a school specially intended to help, and improve, weakly children the classes should be small: in the Schools for Exceptional Children in Norway no class exceeds twelve in number[1]. These statements show that advantages might be derived from carefully studying the temperament and the physical condition of each member of a school community. The higher the proportion of exceptional children, the greater is the demand upon the teaching staff. These principles applied to Public Elementary Education indicate that the best schools and teaching staff are the most required in the worst neighbourhoods.

Grouping of children.

Something may now be said of the interaction of types of children upon one another, and the tendency to strengthening of the characteristics of each type. This interaction of children upon one another is mainly due to the imitative faculty[2]. This principle of imitation explains why children of some defect in development, in whom the imitative faculty is low, do less harm to one another than to healthful children. On the other hand

[1] See *Report of Brit. Medical Association*, p. 17.

[2] Sir Gilbert Blanc said: "The only objects of imitation are gestures and sounds, and by these are also transferred from one individual to another, the emotions of the mind of which they are the natural expressions." *Croonian Lecture*, p. 268. Gestures are imitated before sounds. This is one reason why teachers would do well to study gestures and movements, both in their pupils and in themselves. Imitation is one of the most important means of controlling action in children's brains.

Nervous children with good mental faculty.

nervous children usually have good mental faculty, and much tendency to be affected by imitation; further, action seen in the body of another person is the kind of stimulus which most readily produces imitation, the result being that nervous children excite one another and are not the best companions, although, as has previously been said, they tend to congregate together for companionship. The interaction of children slightly defective may tend towards vulgarity, hence they require constant supervision. Children of delicate constitution and feeble physical health, may be of as many different temperaments as there are types of children. As to conditions of more definite kind, chorea, and hysteria, distinctly tend to spread among children. The actions known as yawning, gaping, fidgetting, coughing may become infectious, and spread through a class; the first signs of such spreading should be dealt with to arrest the infection.

Defective children tend to vulgarity.

Usefulness of imitation.

The converse of the harmful interaction of one child upon another is a brighter side of school life; children teach much to one another. A child will often imitate good action in another child, when it will not imitate our actions; try as we may we cannot be completely children among our children, but those are often the most successful in training who get the nearest to this desideratum.

Types of children.

Paul Dombey.

A few types of childhood may be sketched. It is not uncommon to find some children who are called "old fashioned", you remember little Paul Dombey in his school at Brighton; these children are called "precocious". In many such the weight of the child is deficient, and among other signs of low brain nutrition, you may find spontaneous movements wanting, there is no desire for play and but little general activity[1]. There may be a

[1] Paul Dombey would sit staring in his little arm-chair by the

Spontaneous small thoughts. number of spontaneous small thoughts in these children, some of them resembling those of a more mature age—this condition is a further sign of low nutrition, and is often accompanied by imperfect sleep, dreaming and tooth-grinding. The condition is one of want of impressionability from low nutrition, and is to be met by good feeding, general hygiene and continuous careful training; the companionship of stronger children is very useful, and as thoughts are implanted, and the mental power brought under control, the actions of the child as well as his methods of thought will tend to become more natural.

Want of impressionability to surroundings. Such children as those referred to above need more than others to be rendered impressionable by their surroundings, this is to be effected by causing many things to impress their senses; specially try to effect this by imitation of other children—the actions of other children impress them more favourably, and easily, than action seen in older people who are less like them.

A bad type. A common type of low development is the child with a badly made head, the forehead narrow laterally and shallow, the skin may be dull with innumerable fine horizontal creases from recurrent over-action of the frontal muscles. Sometimes fine vertical lines appear in the mid-frontal region between the eyebrows from over-action of the corrugators. In such case, as in an example given in Lecture VI. p. 112, that kind of management which lessens over-action in the forehead for the moment is that which is good for the child. Improvement may occur in such cases. The child may be slow

fire, for any length of time. Once Mrs Pinchin asked him, when they were alone, what he was thinking about. "You," said Paul, without the least reserve. The child was small, without spontaneous movement, and spoke as older people might do.

in all his actions; he may keep his hands out long after the other children have put theirs down, it is long after the word of command before his hands are held out, he often looks to see what others do before he does the same. This last fact shows that sight may, through imitation, be more effectual than a word of command in effecting the desired result. *Slow action.*

A low class mental condition is sometimes indicated by the tendency to repeat a question asked of the child. "What day of the week is it?" and the child replies "What day of the week is it?" and does not answer the question: some of these children also tend when writing to copy or repeat their work. *A low form of mental action.*

The School as a Corporate Body. The average School, consisting of a sufficient number of pupils congregated for educational purposes, may be supposed to consist of children within a certain range of age, who represent in the aggregate the various types of children met with in the outside world, in about the relative proportions in which they exist in society of the same social class. This arrangement is probably the best for mental culture, and the formation of character. Deviations from this average community may be, and often are, brought about by artificial circumstances—and in many cases it may be questionable whether the artificial arrangement is better. Entrance examinations, prizes and scholarships, have an undoubted tendency—an effect planned for by the management—of attracting to the body corporate individuals of a certain kind, viz., such as already show an intellectual capacity above the average. Again, some private schools are situated where every healthful arrangement is amply provided for, and under a genial and kind hearted management, are open to weakly and delicate children, the numbers being small, and health considerations being *The school.* *Prizes.* *Schools for delicate pupils.*

Artificial grouping of pupils. placed before intellectual competition as the end aimed at. In such cases the corporate body is artificial; each individual must be trained according to capacity, and the management, if wise, will exercise an arbitrary government of each child, such as is always necessary in the home where some of the rules laid down for one child are not applicable to others, in such items as work, play, rest, feeding, rising and going to bed. The boarding school is after all a limited community; a pupil cannot ordinarily be expected to be better than children at large, and is a possible source of danger if his development is much worse than the average.

Primary schools. Among *Primary Schools* there appears to be much difference between those that have to receive all the children compelled by law to attend, and voluntary schools which are not necessarily obliged to keep exceptional or troublesome children. The coexistence of Voluntary and Board Schools in a district, is likely to lead to the aggregation of the more difficult children in the school which is not free to select its members. Exactly what the average percentage of delicate, feeble brained and nervous children may be in the school population is not yet known, but where it is much higher than the average there is evidence that it may be desirable, in the interests of the school, that some at least of the exceptional children should be removed from the general classes; from examinations, and the Standards instituted under the Educational Code, and placed under special training more suitable to their requirements[1].

The School as a corporate body may be viewed in another light by the parent who wishes only to do the

[1] See evidence of Dr Shuttleworth and the author before the Royal Commission on the deaf, dumb and other children requiring *exceptional* education.

best for his child—wisely or unwisely he wants a perfect place for his boy, where all the surroundings are good, and, even if he knows in his inmost mind this *his* boy is not perfect, he desires the more that all the other members of the community may be so good as to benefit him by the force of Imitation. The parent when placing his child in a school can hardly be expected, even if he is asked, to say what defects or faults his child may have, except as to matters of physical health; hence protection of the community from the importation of too many delicate, nervous or defective children, is a responsibility that must ever remain with the head of the school. To form a right judgment upon the suitability of a child to enter the school, necessitates on the part of the Principal a careful study of children from every point of view. Surely the test of a written entrance examination is far from being any complete evidence as to the child's worthiness to become a member of the school community. I do not wish to seem to urge that only perfect children should be admitted to the school, far from it, I think that various elements may wisely be added from time to time so as to give the special character to the community that may be somewhat lacking—some may be needed to give the element of physical strength and capacity to lead in athletics, others to elevate the moral tone or raise the possible standard of intellectual work. A set of simple athletes, or a large group of strongly intellectual children, would not improve one another so much as the two classes duly blended.

The parent's view of a school.

Responsibility of the Principal.

Among the many difficulties that have arisen in the classification of pupils it is very generally admitted that "the age basis" is unreasonable. Any suitable classification must be based upon the intelligence, the attainments, and the physical development and brain-power of

the children. Such general statement may be accepted, and immediately the question arises how to judge of the development and brain-power; this is a scientific problem, and an attempt has been made by a Committee of the Psychological Section of the British Medical Association to establish a basis upon which such work may be done. The general methods of observation employed were explained in my earlier lectures; some results of this enquiry will be given presently.

Intellectual faculty and brain state.

Teachers who deal with the intellectual faculties mainly, generally know more of the mental than of the physical and general brain state of their pupils; in school inspection we find it more easy to detect physical and general brain states. A child may have grave mental defects, and may yet present no obvious defects that the eye of the observer can detect. Questioning and somewhat prolonged examination are needed to detect mental defects, when no obvious signs are observable. The physical observer may be sure of the signs he observes, but to see no defects does not prove that the child is normal.

Training capacity for expression.

In these lectures I have mainly dwelt upon methods of making observations, and the results obtained, as a means of classifying pupils, there remains the question of managing and providing for the proper training of children. In the ordinary methods of literary training, the thought or mental impression upon the brain may be produced without a capacity in the pupil for its expression in words. A very intelligent master of large experience has assured me that, when giving an explanation of a geometrical problem and asking questions thereon, he is often content if he sees a facial expression of intelligence in his pupils without capacity for giving a verbal answer, trusting that the power of expression will come

later. A boy may work out a geometrical problem by a diagram, but fail to give a verbal demonstration—that is he may give a mechanical explanation only.

Judgement and expression.

"The judgement" and the "executive faculty" involve very different kinds of action in the brain. To form a judgement is a mental process occurring among the brain-cells. The capacity for such action results from former impressions received, or inherited; this depends probably upon very fine changes in the brain, and these must take place before the expression of the judgement, whether that be by words or by a manual act. These two factors in training—that of producing mental impressions, and secondly, getting an expression of mental action in words, or in acts—are very different matters. To get expression of thoughts and mental states is of course very desirable, even in the earliest stages of childhood, but at first we must be content to control spontaneous thoughts and the tendency to spontaneous action, as in organized play, or by listening to and correcting the almost senseless and unintelligible prattle of the young child. Later we may try to produce mental faculty by making impressions, being satisfied with a gleam of intelligent expression; while in the more developed brain we look for, and cultivate the correct expression of thought by words and action in harmony with the surroundings.

Training weak children.

There are some children whose nerve-signs are increased by any prolonged period of ordinary school-work—yet these weak children need training, even more than others, for they have to make their way in the world as well as bear their own infirmities. It seems likely that in wise arrangements for such children, manual training and sloyd as a part of their curriculum might be useful. It appears that sloyd is quite capable of being adapted to

Sloyd for weak children. the individual necessities of the child, it is a means of coordinating his movements, and thereby regulating the action of his nerve-centres. It seems likely that three hours or so in the week taken from the school-room and spent at sloyd might help to restore the balance of brain action in many nervous, over-mobile, ill-balanced pupils. Sloyd is a means, we are told, of producing action through the eye upon the brain as a governor of the hands, and thus it gives real mental training. It has been said that "Manual training is training in thought-expression by other means than gesture and verbal language, in such a carefully graded course of study as shall also provide adequate training for the judgement and executive faculty." *Training in thought-expression.* The phrase "training in thought-expression" refers to the educational methods used to stimulate or set going the molecular changes in the brain which correspond to "thought" or mental action, and the expression thereof. The sight of an art model may produce the necessary *Modelling.* brain impressions in the pupil; the modelling of a lump of clay is one mode of partially expressing his thoughts. One pupil may better express the mental impression produced upon his brain by the use of words, another by the pencil or by working on a lump of clay. In any case, to produce the mental impression is one effect of the educational methods employed; to get an expression is a later achievement on the part of the teacher, and is more difficult of attainment. Manual training appears of special value for the very different classes of pupils—those who have but little capacity for mental work on the lines of literary culture, and the very nervous but bright children who have much spontaneous thought, and are soon exhausted by ordinary lesson work. In the case of nervous, irritable children, quick in mental action, spontaneous activity of the brain-centres is shown by the large amount

of spontaneous movement which they exhibit; and on the intellectual side we see activity displayed, often up to the point of producing exhaustion, in the amount of talk, in the questions asked, or worse still, in habits of introspection or vague, undefined 'talking and thinking to himself,' and excessive imagining[1]. Such children no doubt are best cultured in part by methods of manual training, and they require education in the faculty of receiving impressions capable of controlling them, rather than the implantation of more thoughts—their spontaneity needs to be controlled to co-ordinate action, not stimulated to further activity.

Exhaustion from untrained thinking.

Introspection.

Many reasons might be given in favour of education and training for the young, and much might be added as to the necessity of special training for those who are about to adopt the scholastic profession as their calling in life. The objects of training should be not only to prepare the man to do his work well and with profit to himself, but also to prepare the body and the brain for the strains that will surely be made upon them in the pressure of active life, rendering him apt for labour, full of power and resource, strong, and not easily broken down by temporary trials, adverse circumstances, or overpressure. This principle is amply exemplified by observations in practical life, and it would be well if it were clearly understood by those who, as guardians and teachers, have to prepare the young for their future career. It is not uncommon to see such cases as the following: a lad leaves school, where he has worked but indifferently at his lessons; on entering the office he is obliged to work hard at duties that are strange to him, so that in a few weeks he becomes fatigued and then exhausted by an amount of work which those accustomed to the office

Training strengthens the brain.

Breakdown from want of training.

[1] Such a child is well described in "Sara Crewe."

Trained teachers.

routine are trained to bear without difficulty. Similar cases may be seen among teachers who have not been fully trained to bear the responsibilities that fall upon them. Such strains must come to all, to the strong and to the feeble, and it is a wise policy to train, during their educational career, those who are delicate in structure or balance of brain, or suffer from nerve-conditions, in order that in after life their strength may be adequate to bear the labours and strains which would break down the nerve-system of an untrained man. Training properly conducted, so as to develope all the mental faculties, and especially those that will be most called upon in the business of life, is the best means of guarding against failure of mental and physical power, and also is the best safeguard against the development of inherited weakness.

Teachers and parents.

The school confers benefits not only on children, it also aids parents in the right discharge of their responsible duties; the relations of teachers and parents are not however, in some cases, as intimate and harmonious as they should be between those who have a common love of children. The interest of the school may be to obtain good intellectual results among the scholars, the parents may be indifferent or over-anxious. The head-mistress may say the child is always better when attending school regularly; the mother may say that school work tries the girl, and that she is always fatigued in the evening, or excited and irritable. The best means of coming to an agreement as to what is good for the child, is to observe the child carefully at various times. The

Notes of children.

mother, as having the greatest interest in the individual child, and more time for observing her, might be requested to make some notes as to when she sees the signs of fatigue and what points she actually finds present, also to keep a time-table of work done, the time

of rising, retiring to bed, meals, etc. as far as they concern home life. I suppose the parent can always obtain a copy of the school time-table. A good mutual understanding is much more likely to follow from exact observations, than from a mere expression of opinion on either side. After such enquiry and comparison, the mother may learn to see that late hours, indolence, and dawdling habits are causes of waste of time and loss of strength, and that more regular work is better for mind and body; the necessity for providing regular and suitable meals and a quiet study for home work must not be overlooked.

School Reports. If the component elements of the School, considered as a corporate unity, be a matter of importance, it will concern the Management to know something of each of the pupils, as to their development of brain and body, and as to their power and brain faculties, both mental and otherwise. As an attempt to advance in this direction by scientific methods, a Committee was appointed last year by the British Medical Association.

Reports on schools.

Inspection of Schools, after the manner employed by this Committee, is not intended to demonstrate the mental action of the children, only the brain condition as indicated by far more general and rough tests than those necessary for ascertaining their intellectual standard. Questioning is usually necessary to demonstrate the purely mental action of the brain, and this has purposely been omitted in most cases by the Committee.

At the request of my colleagues on this Committee I prepared the following method of procedure in examination of the pupils.

Suggestions for making observations on Children in Schools.

Signs to observe. In reporting on a School it is necessary to record the number of children seen in each class; it may be well to note the ages of those reported in the Schedules. It is assumed that the children seen, but not reported in the Schedules, are normal, or average, in our opinion, and that of the Teacher.

It may be well to note the occupation of the class under observation, and the date of the last Government Examination.

The following suggestions are made as to points that may be observed, and the terms used in describing them :—

PHYSIOGNOMY, DEVELOPMENT, SHAPE, MALFORMATIONS OF HEAD, ETC.

Head.—Large, hydrocephalic—Small—Microcephalic = Circumference below 17 inches—Well-shapen—Forehead, wide, overhanging, narrow—Angle oblique, vertical —Oxycephalic = Elevated head—Dolichocephalic = Long-head — Scaphocephalic = Keel-shaped forehead — Head lumpy, rachitic, forehead hairy, etc.; Frontal prominences marked — Measurement between eyes — Fontanelle in young children—Circumference and transverse measurement from one ear passage to the other.

Jaws.—Large, heavy; underhung—Prognathism—Palate vaulted, narrow, Cleft.

Teeth.—Prominent—Enamel defective—Teeth ground —Notched or Pegged—Number.

Nose.—Wide and coarse—Indented at root.

Ears.—Well shapen, outstanding—Asymmetrical—Helix contracted—Lobe adherent—Hearing.

Lips.— Thick — Thin —Sore— Fissured. Mouth— large, small. *Signs to observe.*

Hair.—Coarse—Fine—Colour.

Eyes.—Squint—Spectacles—Coloboma—Eyesight.

Eyelids.—Epicanthic folds excessive—Dark ring under eyes. Palpebral fissures small.

Face.—Flat—Round—Fat—Thin—Features well cut, heavy, coarse.

Movements, Postures, etc.

Expression of Face.

Head.—Flexed—Extended, inclined to right, to left —Rotated right, left.

Eyes. — Not readily fixed — Restless — Frequently moved horizontally, vertically — Temporary varying squint—Nystagmus.

Face.— Mobile — Choreic — Immobile — Rigid — Staring — Stupid — Intelligent—Expressionless — Fixed Expression.

Face. — *Frontal Zone:* Frowning, *i.e.*, Horizontal furrows—Frequent frowning—Corrugation, *i.e.*, Vertical furrows, slight or marked. *Middle Zone:* From brows to lower margin of orbits—Eyelids wide open—Half-closed, ptosis—Under eyelid full, orbicular muscle relaxed—Good tone—Winking frequent. *Lower Zone:* Below orbits—Frequent grinning, one-sided grin—Snarling, uncovering canine tooth, right, left—Pursing lips, *i.e.*, Contraction of orbicularis oris—Mouth open—Jaw often depressed.

Spine.—Symmetrical—Shoulders equal—Lateral curvature, left shoulder down—Shrugging shoulders—Lordosis, lumbar curve excessive when hands are held out —Round backed.

Signs to observe.

Upper Extremities.—When held out—Are they level with shoulders? Both on same level? Movements at shoulder—Let hands be held palm down with fingers separate.

Hands.—Each hand should be observed separately.

Finger Movements.—As seen in hands held out—Flexor-extensor twitches of one, or of all digits—Lateral movements of the digits.

Movements.—The parts moving should be named—Movements may be easily controlled by sight of objects, or word of command, or not so—Twitching movements—Tremors—Athetoid movements; the special combinations and series not being those seen in healthy subjects—Automatic movements: Head = Nodding, lateral; Body = Rocking to and fro; Limbs = Various.

Physical Health, Nutrition, etc.

Well-nourished face and limbs—Colour good—Skin clear, thin, thick—Eczema—Cyanotic—Nævus—Rickets, Struma, etc.—Paralysis, Chorea, etc.

Mental Signs.

Power of attention; Power of imitation; Memory—Quickness of response—Use of words, whether ready or slow—Dull in answering simple questions—Whether credulous and easily imposed on—Backward in spelling, ciphering (multiplication table; simple sums), reading or writing—Age of child and length of time in school should be considered—Knowledge of value of current coin—Perception of form and colour of objects—Moral peculiarities—Docile; irritable, passionate.

Speech.—Stammering.

In this way we observed 5,344 pupils in schools in London. *B. M. A. Report on Schools.*

The following table (C) is given to indicate the principal facts observed. In the 5,344 children, the percentage of cases in which notes were taken was 15·13, in the boys' schools 17·93; and in the girls' school 12·03. Several special conditions often coexisted in the same case. Further analysis and descriptions of combined conditions are given in succeeding tables.

TABLE C.

—	—	Boys	Girls	Totals
	We took notes of 809 cases in the schools ...	502	307	809
See Table E	Cases showing signs of nervousness, nerve-weakness, or defect	207	144	351
" F	Cases in which nutrition appeared to be defective	100	84	184
" G	Cases in which mental dulness was reported or observed by us	153	78	231
" H	Cases presenting cranial abnormalities ...	166	65	231
" I	Cases with disease or defect of eyes ...	74	75	149

Among the boys a larger total of cases attracted attention. Cases of Nervousness and Nerve-weakness are here grouped along with cases of Nerve-defect, the distribution of the two subdivisions both as to sex and as to the schools in which they mostly occurred differ largely. The 14 schools seen in London are conveniently divided into two groups, 10 Public Elementary Schools and a group consisting of a large Pauper Industrial School, two certified Industrial Schools, and School for the Deaf and Dumb—these four Schools containing 1413 pupils form a group presenting many signs of "exceptional children."

A group of 351 children (boys 207, girls 144) is given in the report as presenting signs of "Nervousness, Nerve-weakness or Nerve-defect." These are grouped *Nerve cases.*

together as showing 'some nerve-signs,' it is not intended to imply that all these pupils were what is commonly called 'nervous children,' still we saw in each of them some nerve-sign such as should not be present. This group might be divided into two classes, those whose nerve-signs indicate some defect in make and development of the brain, others—often temporary in character,—which signify an over-mobile state of the nerve-centres; the latter class of children often show marked intelligence. Nervousness and mental dulness are often present in an inverse ratio; signs of nervousness are most common among girls, badly made skulls and mental dulness are most common among boys. In the Public Elementary Schools the average of children presenting nerve-signs was 1 in 20; as we follow the distribution of such cases the proportion rises to 1 in 10 for the highest class school, or 1 in 7·5 immediately after the Government examination, falling in the pauper industrial school, to 50 in 1077, and here most of the nerve-signs appeared due to conditions of development.

Cases in which we observed Signs of Nervousness, Nerve-Weakness, or Nerve-Defect are Analysed in Table E.—It is probable that in some of these cases the signs of nervousness or nerve-weakness were only temporary in character.

NERVOUSNESS: NERVE-WEAKNESS, NERVE-DEFECT.

TABLE E.

Distribution of Nerve Conditions	Boys	Girls	Totals	Low Nutrition		
				Boys	Girls	Totals
Infants	14	18	32	6	8	14
Standard I	20	7	27	10	4	14
,, II	11	9	20	6	2	8
,, III	6	14	20	2	5	7
,, IV	6	17	23	2	4	6
,, V	13	9	22	2	2	4
,, VI	11	14	25	4	4	8
,, VII	6	18	24	0	1	1
,, ex. VII	2	5	7	—	—	—
Ten public elementary schools ...	89	111	200	32	30	62
Pauper school	37	13	50			
Two industrial schools	66	14	80			
School for deaf and dumb	15	6	21			
	118	33	151			
Ten public elementary schools as above	89	111	200			
Fourteen London schools	207	144	351			

—	Boys	Girls	Totals
As coincident conditions, we found in the 200 cases in 10 public elementary schools:			
Defective nutrition	32	30	62
Mental dulness	23	20	43
Cranial abnormalities	28	16	44
In the 50 cases observed in the pauper school:			
Defective nutrition	2	5	7
Mental dulness	15	5	20
Cranial abnormalities	12	3	15
In the 80 cases observed in the two industrial schools:			
Defective nutrition	10	4	14
Mental dulness	18	4	22
Cranial abnormalities	13	4	17
In the 21 cases observed in the school for deaf and dumb children:			
Defective nutrition	2	3	5
Mental dulness	4	1	5
Cranial abnormalities	6	2	8

10—2

Nerve cases.

The percentage of these cases was :

		Boys	Girls
Ten Public Elementary Schools	5·08	4·57	5·58
Four Special Schools	10·68	13·88	5·86

The principal nerve-signs are analysed as to frequency of occurrence and as to their combinations in Table K.

Signs of Nervousness appear to be 'Nervous hand posture,' Finger Twitchings and Relaxed orbicularis oculi, Lordosis.

Defects.

Signs of Defect are Frontals over-acting, Weak hand, Lordosis. These conditions are very differently distributed in the ten public elementary schools and in the four special schools as shewn in Table K.

The table given above presents the children in whom we noted some nerve-signs; it is not suggested that all these cases were in any way exceptional, or that they should be separated for educational purposes. An account of thirty-one children who were thought to require special educational care is given at page 8 of the Report.

Note. In Tables E, F, G, H cases are analysed where the coincidence of conditions is frequently met with; cases may present defects in development and at the same time show mental dulness and low nutrition, etc. It will be seen then that no balance of these figures can be taken.

The proportion of nerve-cases in each standard respectively was as follows: *Nerve-cases in standards.*

	Infants	1 in 47
I	Standard	1 in 18
II	Standard	1 in 22
III	Standard	1 in 21
IV	Standard	1 in 15
V	Standard	1 in 13
VI	Standard	1 in 8
VII	Standard	1 in 5
Ex. VII	Standard	1 in 6

When stating that we saw some nerve-sign in a child, we do not mean to assert that such child was to be considered as exceptional from the educational point of view.

The increase in the proportion of cases presenting 'nerve-signs' as we ascend the standards is very marked.

Mental dulness was noted in the report of the teachers or when we detected proof of such condition in reply to questions, but our main observations were confined to visible facts observed. Observation of physical facts may indicate conditions of development and nutrition of the brain, but questions put to the child are usually necessary as indications of intellectual power. *Mental dulness.*

The distribution of mental dulness in the schools visited is given in the Report of the Committee; the following table shows the distribution in standards for the 10 Public Elementary Schools, and certain coexisting conditions which may have something to do with causation.

Mental Dulness was observed or reported to us in 231 *cases.*—It is probable that many more children were

Mental dulness. mentally dull; of those noted, some attracted attention in other ways, and some were presented to us by the teachers. The method of examining children by facts observed without questions asked may indicate the condition of development and state of brain, but it is necessary to question the pupil in order to demonstrate mental aptitude or its absence.

TABLE G.—*Cases of Mental Dulness.*

—	Boys	Girls	Totals
Infants	26	17	43
Standard I	12	5	17
" II	6	8	14
" III	11	2	13
" IV	6	4	10
" V	14	1	15
" VI	1	3	4
" VII	3	2	5
" Ex. VII	—	—	—
In the 10 public elementary schools	79	42	121
Pauper school	38	15	53
Two industrial schools	32	19	51
School for deaf and dumb	4	2	6
	74	36	110
For the 10 public elementary schools (as above)	79	42	121
For the 14 London schools	153	78	231
As coincident conditions, we found in the 121 cases in 10 public elementary schools:			
Signs of nervousness, nerve-weakness, or defect ...	23	17	40
Defective nutrition	29	17	46
Cranial abnormalities	21	6	27
In the 53 cases observed in the pauper school:			
Signs of nervousness, nerve-weakness, or defect ...	15	5	20
Defective nutrition	2	2	4
Cranial abnormalities	17	5	22
In the 51 cases observed in the 2 industrial schools:			
Signs of nervousness, nerve-weakness, or defect ...	18	4	22
Defective nutrition	7	9	16
Cranial abnormalities	10	7	17
In the 6 cases observed in the school for deaf and dumb children:			
Signs of nervousness, nerve-weakness, or defect ...	4	1	5
Defective nutrition	1	1	2
Cranial abnormalities	4	1	5

The percentage of these cases was:— *Mental dulness.*

		Boys	Girls
Ten Public Elementary Schools	3·08	4·06	2·11
Four Special Schools	7·78	8·7	6·39

In Table N. further information is given as to the correlation of defects in development or growth and in mental power.

The proportion of dull children in each standard was as follows: *Distribution in standards.*

	Infants	1 in 35
I	Standard	1 in 28
II	Standard	1 in 32
III	Standard	1 in 33
IV	Standard	1 in 40
V	Standard	1 in 19
VI	Standard	1 in 49
VII	Standard	1 in 23
Ex. VII	Standard	none in 47

Speaking generally the points which would stamp a collection of children as low class would be not only low class nerve-signs, but also visible conditions of defect in development of parts of the body.

In Table M. in the Report of Schools an analysis is given of notes of 399 pupils from among 5344.

TABLE M.—*Conditions of Defective Development in Relation to Low Nutrition, Mental Dulness, and Nerve Defects.*

—			Low Nutrition		Mental Dulness		Nerve Defects	
			B.	G.	B.	G.	B.	G.
Total of cases presenting some defects of development, including cranial abnormalities, palate, ears, epicanthus, and other defects (not including squint), boys, 274; girls, 125; total, 399			62	40	86	39	101	44
Cranial defects alone, not in combination			22	12	33	11	31	12
Palate defective alone			6	3	5	12	9	3
Ears defective alone			5	4	8	3	11	4
Epicanthic folds alone			1	5	3	1	1	2
The 73 cases with defects other than those mentioned presented			10	4	18	4	23	4
Cases of Binary Defects.								
Defects of cranium and palate			12	4	12	4	20	7
,, ,, ,, ears			6	0	11	0	12	0
,, ,, ,, epicanthic folds			—		1	0	3	2
,, ,, ,, other defects than those mentioned			5	3	6	2	6	2
,, palate and ears			2	0	7	0	6	0
,, ,, ,, epicanthic folds			1	0	2	2	4	2
,, ,, ,, other defects			0	1	4	2	5	2
,, ears and epicanthus			1	1	3	2	3	0
,, ,, other defects			2	0	5	0	1	0
	B.	G.						
Cases of Triple defects.	24	7	11	6	14	2	11	6
The palate was examined in 459 cases:								
It was found normal in	265	77	—		—		—	
,, ,, abnormal in	77	40	—		—		—	
Defects of palate:								
Arched, narrow, high or vaulted ...	68	37						
V-shaped, not included above... ...	6	2	29	13	22	20	29	16
Of the flat type	3	1						
	77	40						
Defects of ears:								
Symmetrical	37	13	12	2	13	2	15	3
Asymmetrical	27	4	5	2	11	2	9	2
	64	17						
Epicanthic folds:								
Symmetrical or double	27	17	5	4	9	6	6	3
Single or most marked on one side ...	10	4	1	1	1	0	1	0
	37	21						

In the 10 Public Elementary Schools defects of the skull were found in 3% of the pupils, but in the exceptional schools in 8%; in public elementary schools badly

shapen palates were seen in $1{\cdot}3^0/_0$ of the pupils, and in the exceptional schools in $3{\cdot}7^0/_0$.

The number of cases of each binary group of defects may be ascertained from Table N. in the Report.

These cases were not equally distributed in the two groups of schools. Reports concerning such facts as those already quoted seem to be of much importance to teachers and to those responsible for the management of large bodies of children.

Various children as I have seen them in schools are described shortly, the numbers refer to the original reports which I took in examining the 5,000 children in London Schools for the Committee.

Children seen in schools.

67. A girl, aged 13, in Standard IV. Of good physiognomy and good nutrition. Hands balanced markedly in the nervous posture with arching of the spine forward when the hands are held out. This child was seen in a high class school where she had only just been admitted. There appears to be nothing really the matter, but the child wanted training.

77. A girl, aged 12, Standard IV. Physiognomy normal, nutrition fair, but the face rather pale. Hands, in the right side over extended at the knuckles as to the ring and little fingers; on left side hand straight, with thumb drooped. Head left rotated and inclined. Face too motionless, and lower eyelids rather puffy. She had only just been admitted into the school and appeared rather too mobile and nervous, and in need of systematic training.

81. A girl, aged 10, Standard III. Of good physiognomy and good nutrition. Hands, both balance in the "feeble type"; we also observe arching of the spine forward when the hands are held out. She was reported by the teacher as "Fidgety and naughty," and appeared to be in want of drill and training.

An exceptional pupil.

174. A girl, aged 7. Infants. Head looks too large. Palate narrow and high. Hands both held in feeble type; fulness under the eyes; expression is blank, without proper changefulness. Nutrition fair. Reported by teacher to have no mental power; is very silly; attendance is irregular. The mother has been summoned for the non-attendance of this child. The girl appears to be

fatigued and of low mental power. It appeared to be not improbable that this child was made to work at home.

Deficient mental power. 186. A big boy for Standard I. aged 12. His movements and postures, and his condition of general nutrition were normal, but bosses were seen in the frontal regions of his skull. The boy has never learnt to read and is obviously deficient in mental power.

64. A small girl with peculiar physiognomy, 10 years old. Hands held in 'the nervous-posture.' No arching forward of the lower parts of spine, when hands were held out, so that it appeared that the mechanism of the finer movements was more affected than that for the larger actions.

80. A girl, of 7 years, big for her age. Ears outstanding. Hands held both in the 'nervous posture,' with twitching of the fingers; the spine bent forward in lower part when hands were held out. Facial expression bright and changeful. Nutrition good. This child appears to be bright mentally, but rather weak and nervous. Is big for her age and appears to be placed too high in school.

Deaf. Expression good. 346. A boy, 6 years old. The head appeared normal and of good size and proportions; the ears were not quite symmetrical. Expression of face was good. The hands and the body were well balanced; the tone of the facial muscles was natural. Nutrition was good. Teacher said that he was a bright, lively boy, better than average. There does not appear to have been any defect from birth; he became deaf through a fall when one year old. His brain was probably a good one.

Deaf. Nerve-weakness. 349. A boy, aged 10. Forehead shallow but not narrow; palate normal. Ears neither well shapen nor quite symmetrical. Epicanthic folds to the eyes. Expression generally good, but the frontal muscles overact, producing horizontal creases in the forehead. When the hands were held out there was finger twitching, and on the right side extension backwards at the knuckle joints, as in the nervous hand; the spine was badly balanced. He was said to be mentally dull, and a fretful child. He was born deaf. There are three cases of deafness in this family.

Defective make, mischievous. 146. A girl, age 12, Standard VI. Bridge of nose wide, and face flat, with thick lips. Ears normal; skin natural. Both hands held out somewhat after the nervous type. Eyelids not full. Nutrition good. The physiognomy was of low type, and in addition there were slight indications of nerve-irritability. The teacher

reported the child as "untrustworthy, mischievous, and irregular in attendance."

279. A boy, aged 12, Standard VI. Head large, long, broad and flat with frontal bosses. Features fairly well made, ears good. He was pigeon-breasted as the result of rickets, and rather pale and thin. His hands balanced slightly in the "nervous posture." The master reported him as "passionate, most troublesome, and up to tricks." *Head bad shape. Passionate boy.*

304. A boy, small for his age, which was eight years, with well-made features, and good colour, but thin. He was in Standard I. His expression was lively and sharp; the eyes moved well. The hands were balanced in the "Nervous posture," especially the left. There was no undue arching of the back, and no relaxation about the lower eyelids. His teacher reported him as "very good but very nervous, with some difficulty in commencing to speak." *A nervous boy.*

302. A boy, aged 9, Standard I. Head rather large, with frontal bosses and a shallow forehead; palate narrow. His expression was bright; the left hand presented the "nervous type" of balance. The general signs of nutrition appeared average. Teacher said he was very fidgety and not very sharp; very good at arithmetic, but very bad at reading.

785. A girl six and a half years old. She was big for her age. The physiognomy was average, including palate and ears. She had a silly expression, and turned away her head while being spoken to, and would rest her head on the table. General physical health and nutrition appeared fairly good. Teacher reported her as having some fits, though not severe ones, while in school she is troublesome and dirty. She comes of a bad family. *Defective and epileptic.*

821. A boy, 10 years old. Physiognomy and development appeared normal, and nothing abnormal was observed in the movements or balance of the body. He was in Standard IV. Teacher says he has fits in school, lasting some seconds, in which he falls down and kicks. Has had 160 fits in one day.

Such a boy needs the benefits of a good training to prevent mental degradation.

828. A boy, 14 years old, in Standard VI. No defect in physiognomy. The movements and balance of the left hand are good, and he writes with his left hand. The right has been paralysed from birth; he has fits. Teacher says he shows only ordinary intelligence, and has no fits in school. *Paralysed.*

A few illustrative cases taken from my Reports on Schools will show the kind of benefit that may be derived from some accurate knowledge of the development and condition of brain function of individual pupils.

Born deaf. 362. A boy born deaf, age 8 years. He showed too little changeful expression. Physiognomy fairly good, but forehead rather narrow, and the hair comes down too low towards eyebrows. Teeth ground; both hands were held out in the nervous posture; he also presented lordosis of the spine. Nutrition was good. He was fairly intelligent but precocious, with some tendency to vulgarity of behaviour.

Klepto-maniac. 288. A boy, aged 11, Standard III. The physiognomy and the separate features, as well as the movements and postures of the body and the signs of nutrition, etc. presented no noteworthy signs. This boy was reported as "constantly steals in school, seems unable to avoid doing so. He frequently plays truant, but is bright at school work." Such a boy ought to be placed under conditions where he cannot steal.

Rickets. Nervous child. 298. A boy, aged 8, Standard I. Head very large, with good features, and ears not defective. He was pigeon-breasted, and it appeared probable that his large head was due to rickets. Hands, left hand held in "nervous type posture" with twitching movements of elbow and shoulder muscles; on the right side these points were less marked. The signs of general nutrition and the colour of the face were good. He was said to be a sharp quick lad. We thought he had suffered from rickets and was in consequence rather weak and nervous.

Defective. 90. A girl, aged 7, Standard I. Physiognomy peculiar, eyelids misshapen with moderate epicanthic folds. Other features good. Palate rather flat. Balance of body good. Nutrition good, but rather pale. The child appeared to be wanting in proper mental power. Teacher reported "cannot do any mental work, cannot read, just knows the letters."

571. A boy, aged 11 years. Fairly well made, with slight varying squint. Face expressionless and flabby. Palate rather narrow. He does nothing well in school and shows moral indifference; he played as if nothing had happened just after his brother died suddenly of brain disease. Very dull at school work.

A group of selected cases is next given in the form of schedule used in taking notes in schools.

CHILDREN SEEN IN SCHOOLS.

No. of case	Physiognomy, development, shape, malformation, &c., of head. Expression	Movements, postures, &c.	Physical health, nutrition, &c.	Teacher's Report	Report, specially mental status
534 Mary W. Age 9 Standard I.	Palate normal. Ears normal	Fine horizontal frontal creases. Walks badly. Slight divergent squint	Thin	At times appears mentally deranged; is very violent when in this state and strikes other children	"Mental attacks." Frontals over-act. Divergent squint. Thin
571 Ernest H. Age 11 Standard IV.	Head large enough. Facial features good. Ears fair. Palate rather narrow	No changeful expression—expressionless. Hands straight. Orbicularis oculi of good tone. Slight varying squint	Nutrition and colour good. Face rather flabby. "A brother died of 'Hæmorrhage on brain' following an attack of vomiting—quite suddenly"	Very dull; does nothing well. Moral indifference. Played as if nothing had happened just after his brother died suddenly of "brain disease"	Defective mentally. Squint. Not spotted
301 John W. Age 8 Standard I.	Physiognomy defective. Forehead shallow. Ears both defective in middle portion of rim. Mouth small. No epicanthics. Palate not narrow. Head not of good type in form	Hands fairly straight. Expression not good. Orbicularis oculi of average tone	Nutrition fair	Very defective, does not know the letters. No power for arithmetic. Can write from a copy, not from memory	Defective make. Defective and peculiar mental power
564 Harry C. Age 7 Standard I.	Head presents nothing marked. Palate high and rather narrow. Epicanthic folds marked	Balance and movements average. Expression average	Nutrition good	"Cannot make anything of him." Cannot write his name. Very backward	Does not respond to questions. Not due to shyness. Epicanthics

CHILDREN SEEN IN SCHOOLS.

No. of case	Physiognomy, development, shape, malformation, &c., of head. Expression	Movements, postures, &c.	Physical health, nutrition, &c.	Teacher's Report	Report, specially mental status
296 Charles B. Age 12 Standard II.	Big boy for this class. Look of low type. Lips rather thick. Ears not bad. Teeth normal	Hands—both of 'Nervous type posture.' Frontals over-act, producing coarse horizontal furrows. Some jerky movements of head, but these may be from jerking of the body	A fat boy	Very dull, not troublesome	Defective in make and in brain-power. A big, fat, dull boy. 'Nervous hands,' jerky movements
541 Louisa L. Age 14 Standard I.	Head small, circumference 19¾. Transverse. Antero-posterior. Palate normal	Hands held straight, slow in holding out hands to word of command, and they are kept out long. Eyes wandering. Facial expression wanting in intelligence. When reading frontals over-act with corrugation	Nutrition average	Near-sighted. Very dull at lessons, though somewhat improved lately	Mentally defective. Could not carry a message. "Not remarked till reported by Teacher."
305 Edward W. Age 9 Standard I.	Head of good shape. Features good	Hands—both of 'Nervous type posture' with much finger twitching. Expression bright. Eyes steady. Orbicularis oculi rather toneless	Nutrition fair, rather pale	Sharp and good	A well made but nervous child
298 Arthur L. Age 8 Standard I.	Head very large. Features good. Ears not defective	Hands—left of 'Nervous type posture' with twitching movements of the elbow and shoulder-muscles — right less so. Slight lordosis	Nutrition and colour good. Pigeon-breasted	Sharp and quick	Rickets affecting head. Rather weak and nervous

299 Willie S. Age 8 Standard I.	Forehead keeled, presenting a ridge down its centre—also (at site of fontanelle) above the centre of forehead. Ears symmetrical, rather protruding, but not defective in the rim. No epicanthus. Palate not arched	Somewhat wanting in variable expression. Arching of the spine found as the child stands. (Lordosis)	Average signs of nutrition and physical health	"Rather fidgetty, not a strong boy. Has been only a few months at this school"	Somewhat wanting in nerve-power. Fidgetty. Scaphocephalic
323 Flory H. Age 9 Standard II.	Physiognomy good. Ears well made	Eyes move rather much vertically and horizontally while she is looking at me	Nutrition and colour good	"No memory, very trying in school. Stammers at times. No idea of dictation. Not a very good child"	Mentally very low. Eyes fix badly
419 James F. Age 14 Standard II.	Physiognomy good. Palate normal	General expression good. Horizontal frontal creases from over-action of frontal muscles, also some over-corrugation drawing eyebrows together with vertical creases. Hands balance straight. Stammers	Thin	Dull	Low class nerve-signs. Thin. Dull mentally
457 Henry N. Age 14 Standard III.	Head rounded in type, no frontal bosses. Physiognomy good. Palate narrow	Expression good. Right hand balanced fairly straight with thumb drooped. Lateral twitching of fingers on both hands. Forward arching of spine when hands are held out	Good	Bright	Palate narrow. Some nerve-weakness, but bright mentally

CHILDREN SEEN IN SCHOOLS.

No. of case	Physiognomy, development, shape, malformation, &c., of head. Expression	Movements, postures, &c.	Physical health, nutrition, &c.	Teacher's Report	Report, specially mental status
465 Patrick M. Age 15 Standard IV.	Physiognomy inclined to a low animal type of face. Palate good	Too expressionless. Frontals over-act creasing the forehead. Hands straight	Good	Slow in schoolroom work, and also in the workshop	Some defect in make; of low class brain make. Slow in mental and in manipulative action
29 John B. Age — Standard VII.	Physiognomy normal	Hands—balance markedly in the 'Nervous posture.' He corrugates, drawing eyebrows together. Dark about under eyelids. Circular muscle of eyelids relaxed	Average	Very dull, imbibes but few ideas. A good boy and over anxious	Markedly nervous, with signs of exhaustion. Said to be dull. Why is he placed in Standard VII.?
58 Boy Age 9 Standard V.	Physiognomy average. Eyelashes long	The mouth twitches. There is frequent corrugation, drawing eyebrows together. Hands show lateral twitching of the fingers. Body constantly moving	Average	Sharp boy	Nervous boy but mentally sharp
89 Florence — Age 8 Standard I.	Forehead rather narrow	Wanting in changeful expression. Hands balanced straight. Mouth open	Pale and thin. Has a cough	At times seems wanting mentally, and will then give ridiculous answers	Probably defective mentally. Possibly has 'petit mal' or slight epileptic attacks followed by temporary mental disturbance

CHILDREN OUT-PATIENTS AT LONDON HOSPITAL.

No. of case	Physiognomy, development, shape, malformation, &c., of head. Expression	Movements, postures, &c.	Physical health, nutrition, &c.	Mother's Report	Report, specially mental status
— Alice T. Age 11 Standard II.	Head circumferences 20 inches. Slight epicanthic folds. Palate narrow, not vaulted. Ears normal. Head small, forehead shallow	Want of changeful expression. Orbicular muscles of eyes relaxed. Lordosis. Hands fairly balance. No marked over-action	Pale. Thin. No known disease	Tries to get on at school	Has been away from school 12 m., now attending. Capable of working quietly. Delicate child
— Harry S. Age 8 Standard II.	Well grown. Physiognomy normal	Hands fairly straight, rather twitchy in fingers. Muscles of eyelid fair tone	Fits—languid. Rather thin. Ill a day or two after fits	Fits—2—3 a year. Good and willing at school. Not very bright. Very passionate. May hurt other children	Two months from school. Irregular at school
— Frederick P. Age 8 Standard II.	Physiognomy normal	Hands fairly straight, slight weak hand—left. No finger twitching. Wanting in changing facial expression	Complains of "shortness of breath." Disease of valves of heart. (Loud mitral bruit.) No complications. Able to attend school. Rather slow. Has had rheumatism	Removed from school by doctor. Likes school	From school 6 weeks —not away before
— Margaret C. Age 14 Standard III.	Physiognomy good	Balances good. Expression good	Not thin—Epilepsy? Ill 3 months, worse 14 days: "falls on head." Eats well	Bright mentally. Good girl. Says name is better off books of the school	From school 12 m., taken away by mother

CHILDREN OUT-PATIENTS AT LONDON HOSPITAL.

No. of case	Physiognomy, development, shape, malformation, &c., of head. Expression	Movements, postures, &c.	Physical health, nutrition, &c.	Mother's Report	Report, specially mental status
— Henry S. Age 8 Infant	Head large, circumference 22 inches. Coarsely built, not lumpy. Right ear poorly made, left normal. Palate high and arched	Chronic choreic movements from birth. Extremities, face, tongue, eye choreic. Can walk—sometimes falls down	No bruit. No rickets. Nutrition good. Never laid up with illness	Mother wishes him at school. Has never learnt his letters. Has only been to school 3 months	Fit only for infant school
— William T. Age 8 Standard I.	Physiognomy good. Palate and ears normal	Hands—both slightly in nervous posture, not many finger twitches. Body sways about much. Clicks tongue. Slight chorea 4 m. Eyes unsteady. Altogether too much movement	Thin	Not at school 4 m., because of fidgeting. Likes school. Goes to Sunday-school. No bruit	Might be in a quiet class but cannot write
— Emily W. Age 9 Infant	Head, circumference 19·25 inches; transverses 12·25. Forehead narrow—head obviously small. Ears normal. No epicanthics. Palate average	Cannot answer questions. Over-mobile. Holds hands out to command	Thin, pale—constipated. No disease. Obviously ill-developed. No bruit	Has been at school 6 years	Very defective in development and mental power
— Emily G. Age 10 Standard III.	Physiognomy good. Well grown but thin	Marked chorea—3rd attack. Hands—marked 'Nervous posture.' Much chorea	Mitral disease. Never rheumatic fever. Thin. Squint	Attends school when she can, but is often away. Often head aches	Fair scholar. Cannot get on with writing. Likes school. Not fit for larger school
— Arthur W. Age 10 Standard IV.	Physiognomy normal. Eyes, ears, skull, palate, normal	Hands well balanced, no twitching. Muscle of eyelids not relaxed. Tongue rather mobile	Has had fits 3 years, has had 6—8 a day. No bruit	Not dull. Speaks well. Bright	Attends school, St Mary's. 821 See School Report. Should be at school

CATALOGUE

OF A

MUSEUM OF NATURAL HISTORY.

11—2

CONTENTS.

PART II. ILLUSTRATING THE STUDY OF SERIES OF ACTS OF GROWTH.

CATALOGUE.

IN training students to observe and think about living things a collection of specimens has been found useful, and the catalogue of such a museum is now given. It is hoped that this, while illustrating the principles put forward in preceding chapters, may indicate to School Teachers new methods of training their powers of observation and making logical inductions therefrom, as well as suggest methods of conducting object lessons and science classes, so as to give more mental training than is sometimes conveyed by science instruction.

Physiology illustrated.

Specimens are here arranged and classified for the purpose of illustrating the principles and methods of action seen in nature. Illustrations will be afforded of the proposition that "all vital phenomena must occur in a living thing, and all vital action necessitates not only supplies of food-material, but also stimulation by forces from without." All organic specimens are the results of growth. Specimens will be presented showing how physical forces may determine and control growth; some evidence may be afforded that physical forces may probably determine the evolution of an individual and of a species. Specimens are drawn from widely different classes of objects, among the lowest are inorganic objects, while amongst the highest results of organization is the human brain, which can only be studied efficiently in the results or outcome of its action. It may be shown that the methods of action in growth are similar to certain observed methods of brain action.

Growth and Movement.

There is an essential difference between studying nerve-muscular movements, and the outcomes of acts of growth, for in such specimens we see readily the action in the subject, its results may be less obvious, in observing movements we see the outcome of action in the nerve-centre, not that action itself.

In the first part of the Catalogue each specimen is usually described as a single object; action is usually described as seen in an individual, thus the examples are here presented as simpler than the illustrations used in Part II. which are usually presented as series of acts of growth seen in two or more subjects or parts of the thing described.

Specimens may first be demonstrated where we can easily observe the visible outcomes of growth—see germinated seeds, buds, leaves, plants, and flowers.

PART I.

Germinated seeds indicating processes and modes of growth.

1. **Pea seeds dissected,** showing the embryo and its testa or covering. The embryo has two large cotyledons, the germ lies between them and consists of the plumule and radicle.

2. **Wheat seeds dissected,** showing testa, perisperm, and embryo with one cotyledon. The perisperm is a store of material.

3. **Models of seeds** on an enlarged scale.

4. **A series of germinated** peas corresponding to ten days of growth. They grew under favourable circumstances of light and food supply.

Remarks. If a pea seed be placed on damp moss and kept in the dark at a sufficient temperature, the access of air being free, it soon begins to sprout. The seed swells, and growth occurring in the embryo is followed by protrusion of the radicle, later the covering of the seed splits and the embryo stem rises into the air bearing a delicate tuft of leaves.

The ascending axis of the seedling as it grows is seen to be bent a little below the apex, and the arched neck of the stem with the tender tuft of leaves pointing downwards, is pushed upwards by its elongation. This arched condition, *this result of* growth, is due to unequal elongation of the two

sides of the stem, that which grows the quickest becoming convex as a mechanical result. One word describes the arching of the stem—when we seek the cause thereof we must observe separately the two halves of the stem and we find that action is unequal in the parts and the arching is a mechanical result thereof.

Movement in seedlings.

5. Tracings of movements of circumnutation. C. Darwin.

The movements of the apex of a growing stem were carefully traced by Charles Darwin; the apex moved in a more or less elliptical curve with many zigzags. This movement results from the unequal state of congestion of the vegetable cells, the side of the stem on which for the time the turgescence is greater being for the time the convex side; this turgescence may be followed by permanent growth. C. Darwin in his researches has shown that apparently every growing part of every plant is continually moving (circumnutating), though often on a small scale. "Even the stems of seedlings before they have broken through the ground, as well as their buried radicles, circumnutate, as far as the pressure of the surrounding earth permits. In this universally present movement we have the basis or groundwork for the acquirement, according to the requirements of the plant, of the most diversified movements." Thus the movements of the stems of twining plants, and the tendrils of climbers, result from a mere increase of the amplitude of the ordinary movements of circumnutation. The movements of the so-called sleep of plants; the movements of various organs towards the light are all modified forms of circumnutation. There is always movement in progress, its amplitude and direction may be modified by external stimuli. In the growth of plants, especially while they are young, it is the rule for first one side, and then another of the organs to grow more rapidly than the rest, curvatures being thus caused, the convexity of which always indicates the side that is at the time growing most rapidly. If another side then grows more rapidly, it becomes convex, and the curvature changes its direction. These curvatures are caused by the unequal growth of

Bendings of growing plants.

different sides of an organ, and have been called by Sachs "Nutations." These nutations occur most evidently when growth is very rapid. Very common is it to find the apex of erect stems above the curved growing part to move round in a circle or ellipse, the region of most active growth moving gradually; this Sachs terms "Revolving nutation." As regards the stem of a plant which happens to be bent towards the north, it will gradually bend more and more towards the east till it faces the east, then towards the south.

It has been shown by Sachs and by C. Darwin, that all parts of the plant move constantly, both the root and the apex of the stem constantly bend in more or less circular tracts. This spontaneous movement is called circumnutation.

In the germinating seed, the radicle or root of the embryo plant first protrudes from the seed coats, and at once begins to circumnutate, or move its apex in the form of irregular ellipses; this movement continues probably as long as growth continues. C. Darwin speaking of circumnutation says: "Until recently the cause of all such bending movements was believed to be due to the increased growth of the side which becomes convex; that this side does temporarily grow more quickly than the concave side has been well established; but De Vries has lately shown that such increased growth follows a previously increased state of turgescence on the convex side."

The cause, then, of the movements called circumnutation is the unequal growth of the different portions of the radicle, the side upon which growth is greatest in quantity becomes convex. When growth becomes more on one side the position of the convexity changes, and the apex of the root is moved accordingly.

When in place of looking at the results of the movement of the apex of the radicle of the pea plant as traced upon paper, we come to look at the minute changes in the mechanism which produce the movement, we find it necessary to subdivide the thing observed, the radicle, into the parts which can swell or grow as individuals, i.e. the cells of which

it is composed, and we look at action in separate groups of cells arranged around the circumference of the stem.

We see that the separate portions of the seedling plant may act and grow independently of one another, and that such mode of growth may result in movement.

6. **Bean germinated.** The ascending axis is extended by growth, and its arched form is due to unequal growth at the two sides. As a result of this mode of growth the plumule is dragged out from between the cotyledons, base foremost, and also it is protected from injury—these are two important results of this mode of growth. Growth results in movement. *Seeds.*

Note.—It cannot be said that the plumule extricates and places itself where it can meet the light, but this results from the action of growth stimulated by moisture and heat.

7. **Beans in various stages of germination and growth.** As an outcome of growth the plumule is well advanced towards the light and air which are essential to assimilation and nutrition.

8. **Sycamore seedling.** The ground line is indicated, and it is seen that the cotyledons are exposed to the air and light, and when chlorophyll is produced in them they assimilate.

9. **Sycamore.** An older plant with foliage leaves. Observe the difference in form of the cotyledons and the later foliage members. The cotyledons here become organs of assimilation, not mere stores of material; in the sycamore seed they are much smaller than in the case of the bean.

10. **Mustard seeds** germinated. Cotyledons produce chlorophyll.

11. **Germinated seeds of various kinds,** showing cotyledons of various shapes adapted for assimilation or storage, also showing their sensitiveness to the action of light, and their duration in the life history of the plant.

12. **Seedling peas.** A. Grown with a favourable amount of light. B. Grown at the back of a room, with deficient illumination. Note the proportions of the eaves and the stem in the two cases. *Light and darkness.*

Remarks. It is seen that some seeds have cotyledons whose modes of growth render them stores of food-material, while others assimilate.

13. Buds. Specimens illustrating modes of growth and the separate growth of the parts of living objects.

14. Horse chestnut buds, in various stages of development. The specimens show bud scales, which are probably modifications of the basal portion of the stalks of the outer leaves. Observe their low organisation, their relative growth to one another and to the leaves, their curvatures in early and later specimens, and their temporary duration. These bud scales protect the embryonic leaves. See Asa Gray, *Structural Botany*, p. 41.

15. Rose. Foliage bud.

16. Rose. Flower bud.

17. Chestnut, expanding terminal bud, producing flower and foliage.

18. Nasturtium buds in various stages of growth, showing the varying ratios of growth of calyx and corolla.

19. Lilac buds. Every gradation may be traced between bud-scales and foliage. The bud scale may be regarded here as the modified blade of the leaf. (Gray, p. 41.)

20. Buckeye (*Asculus parviflora*, fig. 233). The scales are the modified base of leaf stalks. (Gray, p. 41).

21. Alder buckthorn, a naked bud, destitute of scales. (Bentley, 97.)

The buds of the horse chestnut show us some results of ratios in development of parts, or proportional growth. During the winter months the inner parts of the bud are enclosed by bud scales, or modified leaf stalks. As these scales grow the cells on the outer surface increase more quickly than those on the inner side, and as a mechanical result these scales become more concave towards the centre of the bud and envelope it, thus affording protection from the weather and attacks by insects. The young imperfect leaves are closely packed within, and these also grow quickly on their outer side causing them to press towards the centre of the bud. When spring time comes with increased

temperature and consequent increased nutrition, changes occur in the ratios of growth, the inner surface of both bud scales and young leaves grow at a greater rate than the outer surface and thus the curvatures are altered, the inner surfaces become convex and the bud opens. Growth in the scales now almost ceases, while the quantity of growth in the axis of the bud and the leaves is augmented as they become exposed to the action of light, heat, and the atmosphere. *Effect of altered ratios of growth.*

In describing the results of development in a living being, it is often convenient to do so in terms implying quantity of growth.

The mode of development of buds will serve as a good illustration of both ratios of growth and the times of growth in all parts concerned.

The rudiment of a leaf commences as a mass of cells growing outward from the stem; the rudimentary leaves are developed as plates of cellular tissue, such plates of tissue are formed quickly one below another, they envelope the shoot, and growing more quickly than it, they envelope it, and form a bud. This bud-formation depends upon the more rapid growth of the outer or under surface of the leaves in their young state, by which they become concave on the inner (afterwards the upper) side, and pressed upwards to the stem. When perfectly developed, by the latest extension of their tissue, the leaves turn outwards in the order of their age, and thus escape from their position in the bud.

Specimens of leaves illustrating form described in terms of ratios.

22. Willow, lanceolate, median axis and transverse at right angles. Ratio $\frac{1}{6}$.

23. Leaf, oval, median axis transverse at right angles. Ratio $\frac{1}{3}$.

24. Leaf, ovate, median axis and transverse at right angles, crossing at $\frac{2}{3}$ from apex. Ratio of axes $\frac{1}{3}$.

25. Leaf, obvate, median and transverse axes at right angles. Ratio $\frac{1}{4}$ crossing at $\frac{1}{3}$ from base.

A foliage leaf consists of parts, some of which may be absent.

The proportion of growth in the different parts of leaves varies greatly.

26. Rose leaf, showing lamina divided into parts called pinnae, petiole or stalk, and a pair of stipules at the base of the stalk.

27. Lilac leaf, showing lamina and petiole.

28. Leaf or blade of grass. The stalk portion forms a sheath or vagina, and where it joins the lamina a membranous appendage called the ligule stands out.

29. Butcher's broom, showing expanded stalks. It may be noted that the venation is parallel.

30. A pitcher. A highly complicated development of the petiole.

31. Lathyrus leaf, showing a winged petiole, with two stipules, and terminated by a tendril. (Bentley's *Botany*, p. 172.)

32. Bulb of lily showing fleshy scales, or modified leaves.

33. Dionaea muscipula leaf.

34. Snow-ball plant; leaves at lower part of stem are entire, the younger ones higher up are indented on the margin.

35. Convolvulus, upper portion of stem with foliage. The young leaves are long and narrow, the older ones are broader.

36. Nasturtium leaves, old and young. They have similar form but vary in size.

37. Lime leaf. The form is asymmetrical, as there are unequal quantities of growth on either side of the midrib, causing it to be bent, and there is more cellular tissue on one side than on the other.

Leaves are members of the plant called "phyllomes;" their various parts may be variously modified in form or proportions of growth, and in texture or proportions of tissue.

Fig. 10*.

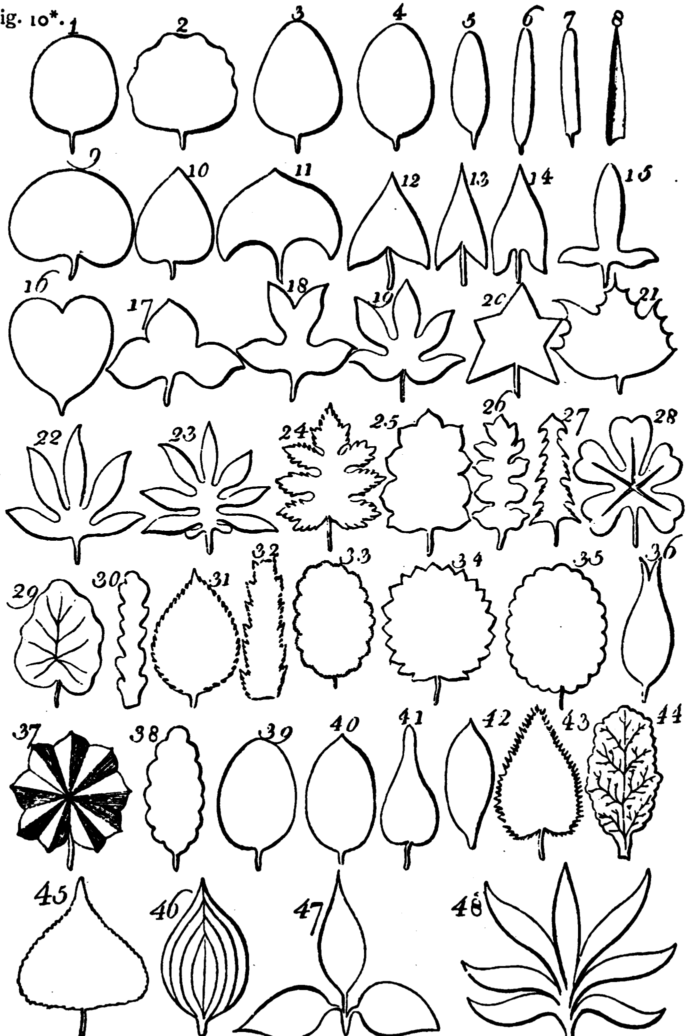

FIG. **1** Round. **2** Circular. **3** Egg-shaped. **4** Oval. **5** Oblong. **6** Spear-shaped. **7** Strap-shaped. **8** Awl-shaped. **9** Kidney-shaped. **10** Heart-shaped. **11** Crescent-shaped. **12** Triangular. **13** Arrow-shaped. **14** Heart-arrow-shaped. **15** Halberd-shaped. **16** Notched at the end. **17** Three-lobed. **18** Bitten. **19** Gashed. **20** Five-cornered. **21** Gnawed. **22** Hand-shaped. **23** Winged Clefts. **24** Jagged. **25** Indented. **26** Indented and toothed. **27** Barbed. **28** Divided. **29** Serpentine (at the edge). **30** Toothed. **31** Serrated. **32** Doubly serrated. **33** Doubly scolloped. **34** Sharply scolloped. **35** Bluntly scolloped. **36** Sharply notched at the end. **37** Plaited. **38** Scolloped. **39** Blunt. **40** Acute. **41** Tapering to a point. - **42** Blunt, but ending in a point. **43** Fringed. **44** Veined. **45** Triangularly spear-shaped. **46** Fibrous. **47** Growing by threes upon leaf-stalks. **48** Finger-like.

Form of leaves as proportional growth.

Remarks on form of Leaves. Simple leaves, and the pinnae and pinnules of compound leaves, may be described in either of the methods used above. To say the leaf is "oval" is to employ a general term; to describe the ratios of the axes is to describe facts seen.

Note. Naming a leaf "oval" is simpler than to describe the proportions of its growth; this method implies fewer acts of thought. If sight of a leaf produces expression by the word "oval" that is one act of thought; to compare the axes is more than one act of thought,—looking at each axis produces two acts of thought. To apply rules of analysis does teach thinking. The general terms, or labels for form, are very useful. Following these lines of giving description we might analyse many descriptions from books.

Duration of leaf determined by its defoliation through intrinsic changes.

38. **Leaf, stalk, and a portion of the stem.** An articulation is seen at the junction with the stem, which begins to form early in the season and is completed at its close. There is a kind of disintegration of a transverse layer of cells, which cuts off the petiole in a regular line, and leaves a clean scar.

Uniform ratios of growth.

39. **Nasturtium plant.** Leaves and flowers with buds in various stages of growth. Observe uniform ratios of growth in leaves preserving similarity of form. In flower-bud the ratios of growth of successive wholes alter as development proceeds; at first the sepals enclose the corolla, later action is greater in corolla.

40. **Iris flower.** The envelope of the flower consists of six parts which in texture and general appearance resemble petals, three of these hang down, and three stand up, forming a sort of canopy over the central parts of the flower. The stamens are three in number; each has a filament or stalk, and a large anther which opens vertically to shed its pollen on the side facing outwards. Just behind each of the three stamens is a style expanded laterally and

looking much like a petal; the stigma is a shelf-like plate passing horizontally across the style just above the anther. No pollen can pass from a stamen to the adjacent stigma.

The adaptation of parts is admirable for conveyance of pollen by a bee, which, standing upon the only landing place, i.e. the recurved portion of the envelope, thrusts its head down below the anther, and on raising it carries off pollen, to be afterwards lodged upon the stigma of the flower which it may visit.

No intelligence without movement.

This flower presents no movements of its parts, hence though it is wonderfully adapted for insuring cross-fertilization by the movements of bees, it is not said itself to show any intelligence.

Enlarging field of observation.

41. Two Iris flowers and a bee. We here observe the three objects which it is necessary to see in order that we may fully understand the life history of the flower. We enlarge our field of observation.

42. Lamium flower. The corolla is tubular with a platform in front and a canopy overhanging the entrance to the tube. The stamens are four in number, the inner pair being the shorter.

43. Salvia flower. The corolla resembles that of Lamium in general form. The stamens are only two in number, or rather two are minute and rudimentary; in the other pair, the two anther cells instead of being, as usual, close together, are separated by a long connective; moreover, the lower anther cells contain very little pollen. Anthers are ripe before stigma. (See Lubbock.)

More adaptation, less pollen.

Salvia flower shows fertilization with less pollen production than in Lamium. Adaptations for action of separate parts are provided and there is less pollen production. This flower also shows a sequence of time of growth, i.e. protandary. This teaches that capacity of parts to act separately may be a means of lessening labour.

44. Chestnut—inflorescence. It is an indefinite form of inflorescence, the buds opening from the lower part of the axis first, the upper ones being the youngest. The opening of the buds shows a series of acts of growth. Ob-

serving an individual flower when open, its parts are seen. The curvature of the different petals varies; the curvatures of the different filaments of the stamens vary, the 10 stamens of the flower are developed in succession, not all together but as a series of acts.

The specimen presents examples at once of many acts of Asynchresis and Imparisynchresis, and Impariasynchresis; and we say it is very beautiful and wonderful, i.e. it stimulates in the brain of the observer the physical expression of admiration.

The specimen will illustrate the need to subdivide the thing observed into parts that can act separately. The times of growth, and the ratios of growth of the separate parts are the essential characters of the specimen.

Series of growth.

45. Sunflower. In a sunflower or other composite flower we have a succession of florets placed on a common receptacle; the florets do not develope all together, but those in the outer zones develope first, the successive zones towards the centre developing one after another in centripetal order. If, then, we consider the successive zones of florets as the subjects observed, we have an example of asynchronous growth. The sequents of this asynchronous growth are important to the flower and to the species. The florets are presented in succession to the visits of insects, to whom they are indebted for effecting cross-fertilization. This series of acts is simple, one subject (one zone) only is active at the same time, so that asynchresis is complete. If the observer prefers to consider all the florets composing the flower head as the individual subjects observed, he will find that no combination of subjects in action recurs, so again it is seen that asynchresis is very great.

Attributes of growth.

Remarks. Having observed examples of visible outcomes of growth, it may be seen that in the descriptions given we speak often of the attributes time and quantity as characters of the acts of growth. Our first purpose is to show the importance of observing the attributes of growth as demonstrated by specimens, and the forces whose action determines those attributes.

The illustrations already given serve to demonstrate the importance of observing the intrinsic attributes of the acts of growth as seen in the specimens resulting from such growth, viz. the time and the quantity of each act.

Specimens showing relations of the Time of Growth, and the importance of noting the Relations of Acts of Growth as to the time of their occurrence.

Examples showing Relations of the Time of Growth.

46. To begin with examples of plant life, the time or order of events is marked as an important element in the following illustrations. In many insect-fertilized flowers cross-fertilization results from an arrangement in the time of development of the organs. Flowers are called proterogynous when the stigmas are protruded and in receptive condition before the anthers have matured their pollen. On the other hand, they are called proterandrous when the anthers mature and discharge their pollen before the stigma of that blossom is receptive of pollen. *Scrophularia* is a good instance of proterogony in flowers fertilized by bees.

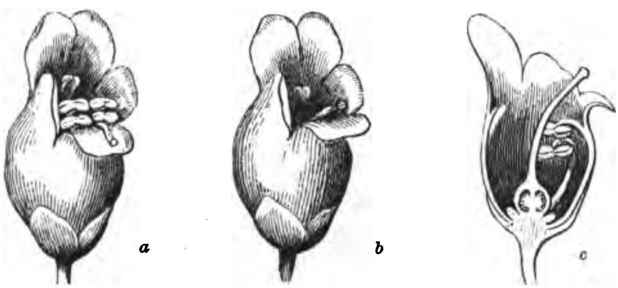

Fig. 11.—Scrophularia.

The following description of this flower is given by Professor Asa Gray[1]:—"The flower is irregular, and is approached from the front, the spreading lower lobe being

[1] *Structural Botany*, p. 220.

the landing-place. Fig. 11 *b* represents a freshly opened blossom; and Fig. 11 *c* a section of it. Only the style tipped with the stigma is in view, leaning over the landing-place; the still closed anthers are ensconced below. The next day, or a little later, all are as in Fig. 11 *a*. The style, now flabby, has fallen upon the front lobe, its stigma dry, and no longer receptive; the now opening anthers are brought upward and forward to the position which the stigma occupied before. A honey-bee, taking nectar from the bottom of the corolla, will be dusted with pollen from the later flower, and on passing to one in the earlier state will deposit some of it on its fresh stigma. Self-fertilization here can hardly ever take place, and only through some disturbance of the natural course."

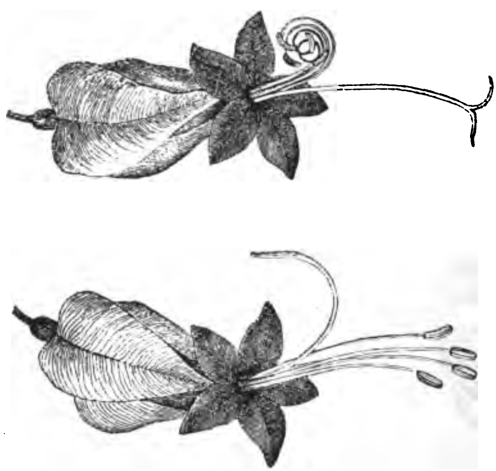

Fig. 12.—Clerodendron.

47. In *Clerodendron* a similar result follows, from the anthers ripening before the pistil. The flower is conspicuous from its colour. The long filiform filaments and style project when the corolla opens; the stamens remain straight, but

the style proceeds to curve downward and backward, as in Fig. 12. The anthers are now discharging pollen; the stigmas are immature and closed. On the second day the anthers are dead, and the filaments recurved and rolled up spirally, while the style has taken the place of the filaments, and the two stigmas, now separate and receptive, are in the very position occupied by the anthers the previous day. An insect flying from one flower to another must transport pollen from one to the stigma of the other. *Relations in Time.*

These examples serve to illustrate the importance of the relations in time among acts of growth.

48. **Orchis maculata**; a young plant which has produced tubers, and no flowers.

49. An older plant, showing flowers developed, and tubers diminished in size.

50. **A jawbone**, dissected, to show the third molars as yet uncut.

51. **Specimen.**

52. **Fuchsia flowers**: in the young flower the stigma protrudes: in the older flower the stamens occupy positions formerly taken by the anthers.

53. **Mallow flower.** Anthers first prominent, later the ten branched stigma protrudes.

54. **Epilobium flower.** Anthers first present, then the style.

55. **Specimen.**

56. **Rose.** Flower-bud gathered in March. It began to open early in season and was killed by frost.

57. **Sprig of almond**, showing annual growth of flowers before foliage.

58. **Sprig of cherry.**

59. **Sprig of wild plum.**

60. **Sprig of hawthorn**, showing foliage before flowers in the course of annual growth.

61. **New shoot of chestnut.** Foliage and immature flowers emerging from the same bud.

62. **Sprig of rose**, showing foliage before flower.

63. **Yellow jasmine** flower before foliage.

64. **Conifer** sprig, showing coincident foliage of five years' growth.

65. **Models** representing the state of dentition of a child at various ages.

66. **Northern fox.** Two examples, showing the different growths of fur according to the time of year.

Specimens showing the importance of describing the Quantity of Growth.

67. **Drosera rotundifolia** plant. Root is small in proportion to foliage.

68. **Lime leaves,** old and young. The size of leaf increases with age up to a certain period.

69. **Viola canina.** Seed from various pods. The number and weight of each lot indicates the success of the flower which produced it.

70. **Flowers.** Mon-androus, Di-androus; Tri-, Tetra-, etc., Dec-androus, etc. Flowers were arranged in the Linnean system according to number or quantity of stamens.

71. **Hop.** Tops of two stems; showing the quantity of growth made in one day.

72. **Aconitum napellus,** sepals and petals. Note various size and form of sepals.

73. **Seeds,** showing examples of large and small cotyledons in proportion to the total weight of the seed.

Note. Observation of the relative quantities of growth in the parts of an object is conveniently spoken of as proportional growth.

Specimens showing the importance of observing Proportional Growth.

74. **Crystals** of similar form and various sizes. Repair of crystals.

75. **Leaves of Eucalyptus;** the young leaves are long and narrow, the older ones are broader.

76. **Seedling maple,** showing the different form of the cotyledons and the subsequent leaves.

77. **Symmetrical and oblique leaves.**

78. **A chestnut germinating.** The bursting of the seed is owing to the unequal enlargement of the embryo and the testa.

79. **Seedling beans** (*Vicia faba*). The arched hypocotyl is due to epinasty, or greater growth upon the upper surface.

80. *Mus. Cat. Osteology*[1], No. 3; No. 14, on development of bones. In a fœtus the ribs become longer and more carved as growth and development occur; this may be seen in the ribs and the femora.

81. Specimens showing distribution of fat.

82. **Crystals of alum** of various sizes. The angles and the ratios of the axis are identical in all these crystals.

83. **Crystals of alum** which have been injured, then placed in a coloured solution. Enlargement has occurred in the original proportions, and repair of the part cut off has taken place through restoration of the original ratios of the axis.

Note. The tendency to the original ratios of growth was retained after the injury to the crystal.

84. **Crystals.** Identical in composition, in size, and form, or the ratios of their axis.

85. **Crystals,** all of same substance. They are similar in the relations of their axis and in form, but not similar in size.

86. **Crystals,** isomorphous; similar as to form, ratios of axis and as to size; but not similar as to chemical composition.

87. **Daffodil flower,** shows great growth of the corona. Observe the high ratio on comparing corona and perianth.

Note. The corona appears to correspond in position, and its origin in development to the ligule of a leaf or petal (phyllome).

88. **Grass blade.** Peteolar portion, and lamina with development of a small ligule at base of lamina. Proportional growth of ligule is less here than in daffodil flower.

[1] Catalogue of Royal College of Surgeons.

89. Campion flower shows proportional growth of ligule and petal.

90. Snowball plant. Observe form of leaves. Upper leaves are entire, the older leaves lower down the stem are indented.

The ratios of growth of parts in a leaf are not similar as growth of the leaf proceeds.

91. Water ranunculus plant. The aerial and aquatic leaves are very different in form or in the ratios of their growth.

92. Wall-flower. Two sets of stamens of different lengths; two forms of proportional growth of anther and filament are presented.

93. Bigonia leaf, asymmetrical; there is not the same amount of tissue on either side of mid-rib.

94. Laurel leaf. Symmetrical.

95. Convolvulus, stem with leaves near apex. Two leaves were killed in early spring and remain attached. The specimen shows that individual leaves alter in form or proportions of growth as they advance.

96. Buds of sycamore showing proportions of scales and leaves as growth advances.

97. Buds of chestnut.

98. Flower-bud—development of—Models. See Sachs.

99. Ovule and its coats: development of—Models. See Sachs.

Examples showing some Sequences of Proportional Growth.

100. Calvaria of children, from birth till twelve months old, showing the actual increase of size of the fontanelle during early growth, and later its gradual closure.

101. A series of pelves at successive ages, showing increase of size, and change of shape of foramina as growth proceeds.

102. Model of stoma of a leaf, showing that variation in the size of the guard-cells regulates the size of the opening.

103. Leaves of cactus, showing that the ratio of parenchyma and vascular tissue is such as to make the leaf succulent.

104. Leaves of holly. The hard character of the leaf is due to the small amount of parenchyma. *Mus. Cat. Gen. Pathol.* 121.

105. Fruits of acacia, in various stages of development, showing air-cavity in the seed-case, owing to proportional growth of seeds and pericarp.

106. Casts of the vertex of the skulls of infants at various ages from birth upwards, showing variation in fontanelle.

107. Fruit of chestnut at various stages. The ratios of growth of carpel and seed is such that no vacant space is developed.

108. Pea fruit. Carpel grows in such ratio to seeds that an air space may exist around them.

109. Nigella fruit. Carpel has split into two layers, of which the outer has grown more than the inner, leaving an air space between them.

110. Bladder acacia fruit. Carpel has grown more than seeds, an air-containing cavity results; it follows that the fruit is light and easily carried by the wind.

111. Poppy fruit. Styles are not developed till fruit is ripe, when their growth elevates the stigma and makes a porous dehiscence.

112. Ash buds. The protection which results from these ratios of growth is seen, and exposure of leaves to light follows.

Antecedents of growth.

112 *a*. A germinating seed. The seed consists of the embryo enclosed in its testa, or covering. As long as it is dry no change occurs; when moistened and kept at a sufficient temperature the process of germination begins by the swelling and growth of the embryo. But the testa does not grow; it may stretch a little, but soon the increased size of the embryo causes the seed-case to split. The splitting of the testa is the outcome of unequal increase in the size of the embryo and the seed-case. It thus differs essentially from the growth of fruits.

Sequence of growth. The sequences of proportional growth may be to produce cross-fertilization in flowers, as is well illustrated by the growth of a flower of the *Compositae.*

In the flowers of the Composite order a special arrangement is found with regard to the relative growth of the stamens and the pistil, which results in cross-fertilization of the flowers; that is, the flower being hermaphrodite is not self-fertilized. The stamens, being united by the margins

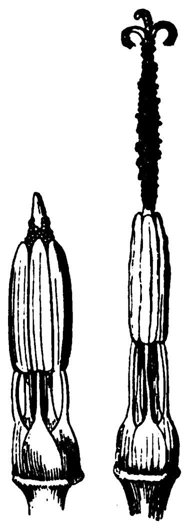

Fig. 13.—Compositae.

of their anthers, form a tube, into which the pollen is discharged. The stamens grow to their full height and maturity before the pistil, which, during the early stage of the flower, is short and immature. When the anthers are ripe and have filled their tube with pollen, the style begins to grow, and passes up the tube formed by the anthers, pushing the pollen powder before it, which now accumulates in a heap at the top of the anther tube. Later, the continued growth of the style brings the stigma as the most

prominent part of the flower; its lobes open and expose the receptive surface. An insect visiting the flower in its early condition, meets with a heap of pollen dust at the top of each floret, and thus dusts its abdominal surface; when the insect later on visits a flower in the later stage of growth, with the style protruded and expanded, it deposits some pollen from the former flower upon the prominent and receptive stigma.

Specimens showing Growth controlled by pressure or mechanical strain.

113. Part of the stem of a plant that has grown bent, owing to its having been strained constantly in one direction.

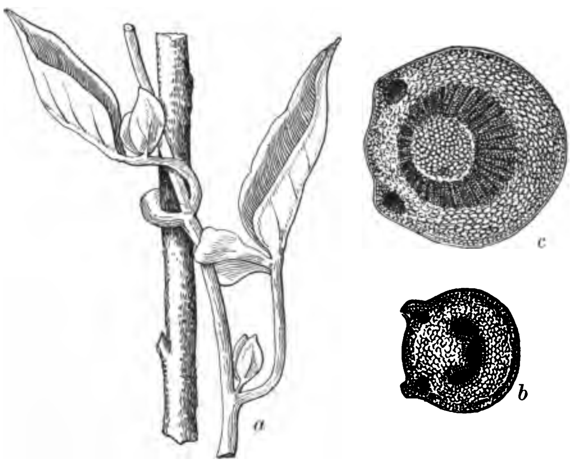

Fig. 14.—Solanum jasminoides.

a. One of its petioles clasping a stick.

b. Transverse section of leaf-stalk not pressed by twig.

c. Transverse section of young leaf-stalk which has clasped a support. After C. Darwin.

114. Leaf and **petiole** of a climbing plant (*Solanum jasminoides*); the petiole being greatly thickened from pressure of the twig around which it is coiled. "The flexible

petiole of a half or a quarter-grown leaf which has clasped an object for three or four days increases much in thickness, and after several weeks becomes so wonderfully hard and rigid, that it can hardly be removed from its support. On comparing a thin transverse slice of such a petiole with one from an older leaf growing close beneath, which has not clasped anything, its diameter was found to be fully doubled, and its structure greatly changed[1]."

115. Head of femur with trochanters, and muscles attached to it. The portions of bone most pulled upon have grown the most prominent.

116. Specimen.

117. Specimen.

118. Foot of Chinese woman, much distorted, atrophied, and hindered in growth by artificial compression. *Mus. Cat., Gen. Pathol.*, 30, Royal College of Surgeons.

119. Specimen.

120. Specimen.

121. Specimen.

122. Specimen.

123. Clematis glandulosa. Two young leaves have clasped two twigs, and the clasping portions have become thickened. C. Darwin. Climbers.

124. Ampelopsis hederacea. A. Tendril fully developed, with a young leaf on the opposite side of the stem. B. Older tendril, several weeks after its attachment to a wall, with the branches thickened and spirally contracted, and with the extremities developed into discs. The unattached branches of this tendril have withered and dropped off. C. Darwin. Climbers.

125. Rattle grass[2] developes suckers on the roots where they touch the living roots of neighbouring grass, and live on them as parasites. Prof. Trail.

126. Vitis hatarinphylla suckers develope when they press on objects.

[1] C. Darwin on Climbing plants.

[2] Rheanthus Christa galli.

Specimens showing the Quantity and Time of Growth controlled by Heat.

127. Fruit grown in hothouse.

128. Similar fruit grown out-of-doors.

129. A hen's egg and a newly-hatched chick. Continuous warmth is necessary to the growth of chick in the egg.

130. A deformed chick due to unequal application of heat to various parts of the egg during artificial incubation.

131. Specimen of a tropical plant. The foliage buds have no scales.

132. Vitis vinifera. A. Portion of branch grown against the garden wall. B. Portion of another branch of same vine from a greenhouse. Both specimens were cut at the same time, that from the house shows large leaves and flowers; leaves on outdoor branch are small.

Specimens showing the Time and Quantity of Growth controlled by Light.

133. Two branches of the same plant, *one* grown in daylight, the other in a dark box. The branch grown in darkness has long internodes, small leaves, and perfect flowers. The effects of light in controlling growth in different vegetable tissues and structures are well illustrated by the next example quoted from Sachs[1]:

"It is remarkable that etiolation does not extend to the flowers. As long as sufficient quantities of assimilated material have been previously accumulated, or are produced by green leaves exposed to the light, flowers are developed even in continuous darkness which are of normal size, form, and colour, with perfect pollen and fertile ovules, ripening their fruits and producing seeds capable of germination. The calyx, however, which is ordinarily green, remains yellow or colourless. In order to observe this it is only necessary to observe a stem of *Cucurbita* with several leaves, the main

[1] *Op. cit.*, p. 675.

stem having been passed through a small hole into a dark box, the leaves which remain outside being exposed to as strong a light as possible. The bud developes in the dark a long colourless shoot with small yellow leaves and a number of flowers, which, except in the colour of the calyx, are in every respect normal. The extremely singular appearance of the abnormal shoots, with normal flowers, showing in a striking manner the difference in the influence of light on the growth of different organs of the same plant."

134. **A young geranium**, showing bending of the stem towards the light; the curvature is due to checking of growth on the side lighted.

135. **A seedling plant**, showing the root bent away from the source of light.

136. **Crustaceans** that have lost their eyes from long residence in darkness.

137. Similar animals, with perfect eyes, from a light locality. Mr C. Darwin gives many examples of loss of parts in a species from disuse. I will quote but one of them:

"It is well known that several animals belonging to the most different classes which inhabit the caves of Cariniola and Kentucky are blind. In some of the crabs the foot-stalk for the eye remains, though the eye is gone. As it is difficult to imagine that eyes, though useless, could be in any way injurious to animals living in darkness, their loss may be attributed to disuse. In one of the blind animals, namely, the Cave-rat (*Neotoma*), two of which were captured by Professor Silliman, at about half a mile distant from the mouth of the cave, and therefore not in the profoundest depth, the eyes were lustrous and of large size; and these animals, as I am informed by Professor Silliman, after having been exposed for about a month to a graduated light, acquired a dim perception of objects."

In this case it appears that the long exclusion of light from the eyes of a species is followed by loss of the eyes.

138. **Two pea plants** of equal age from date of germi-

[1] *Origin of Species*, p. 110, *et seq.*

nation; one has been grown in light, and has assimilated, the other was grown in darkness and when dried weighs less than the seed.

Look at the seedling which has been grown in darkness, and compare its parts with those of a plant grown with due light. That grown in darkness has a long stem and small leaves—this shows that light can control the quantities of growth. A plant grown near a window so that one side of the stem is more illuminated than the other is seen to have the stem bent concavely towards the light, this is due to the action of light in checking growth on one side more than on the other.

139. Tracing of movements of circumnutation, and their substitution by heliotropic movements towards the light. C. Darwin.

Light acting upon the circumnutating stems alters the ratios of action in the vegetable cells coordinating them in one direction; light controls the quantities of action in certain cells, and definite movement of the plant results. The plant does not move itself, the light may regulate its spontaneous movements so that bending in the direction of the light results. When the plant is quietly growing, circumnutating as the stem ascends it is all ready for the special action which follows when light illuminates one side of the stem more than the other, the plant is active, its activity causes its movement, and this spontaneous movement may be controlled to something like an intelligent action; and while the plant is steadily bending towards the light there is very little spontaneous movement.

140. Sinapis alba, seedling; the radicle is bent away from the light. "The conclusion seems inevitable that sensitiveness to light resides in the tip of the radicle, and that the tip when thus stimulated transmits some influence to the upper part, causing it to bend." C. Darwin, *Movements*, 483.

141. Seedling peas nine days from commencement of germination. They have all bent together towards the light.

142. Seedling peas, their radicles were exposed to a strong light and killed by it.

Specimens showing the Quantity and Time of Growth controlled by Gravity.

143. Cell of Vaucheria. This is a unicellular tube; the posterior end bends downward, the anterior end bends upwards under the influence of gravity. Sachs, 760.

143 *a.* The young plant was placed horizontally, the stem has curved upwards, the root downwards, owing to greater growth of stem on under surface, and the root on its upper surface.

Specimens showing the Quantity or Time of Growth controlled by Sound.

143 *b.* **Deformed chicks.** Their proportions of growth are not normal. This appears to have resulted from sudden noises during incubation. *Poultry*, May 16, 1884.

Cellular Growth, or Growth in groups of Cells.

144. Maple leaf attacked by fungus; small loci of cells are overgrown and develope the colour of young shoots.

145. Bramble leaf, margin brown and killed by frost-bite.

146. Bramble leaf. Loci of cells are devoid of chlorophyll and filled with coloured sap.

147. Fucus. A thallus, or cellular mass, with conceptacles which are indicated by the group of hairs proceeding from them. Each conceptacle grows separately, and each branch of the thallus grows independently.

148. Thallus of a lichen. A mass of cells growing independently of one another.

149. Sinapis alba, seedling. Its circumnutation is due to the growth of different groups of cells.

150. Bean germinated. Its growth by hyponasty is due to growth of different groups of cells.

151. Skin of a cat. Each hair grows separately, and the hairs grow similarly as to length and bending in corresponding parts of the animal.

152. Feathers of a blackbird. Each feather grows separately.

Specimens illustrating Double Results of Growth.

Two or more visible results may follow an act of growth, or an impression received, of the results one or more may not be observable at the time.

153. Germinated bean. The mode of growth termed hyponasty results in curvature of the stem, and also in the plumule being bent downwards. This leads to plumule being elevated and protected.

154. Sinapis alba germinated. The ratios of growth in the stem lead to a double sequence, elevation of the cotyledons, and placing them at right angles to the direction of light.

155. Do. do. Its mode of cellular growth leads to circumnutation and aptness for heliotropism, etc.

156. Salvia flower and a lamium. In Salvia the stamens are two in number, and each has but half an anther. The outcome of this modified structure, as compared with the Lamium, is less production of pollen, and greater certainty of cross-fertilization.

157. Oak-sprig with leaves and acorns. Observe the leaves which assimilate and large cotyledons of seeds in which storage occurs. Storage is thus a secondary, and a visible result of assimilation.

158. Lupin leaf. Observe pulvini or motor organs at base of leaflets; their action produced an altered position of the leaflets and results in protection from cold at night.

159. Drosera rotundifolia. Irritation of tentacles leads to more than one result when a fly is caught. (1) Increased secretion. (2) Carrying of the fly to centre of leaf, etc. (3) Its digestion. In a leaf of Drosera rotundifolia if an insect settles on one tentacle, a stimulus is transmitted to the others causing them to secrete and then bend towards

the fly. Here we see the stimulus transmitted to a distance and then produce a double action.

Drosera plant. The following description of *Drosera rotundifolia*[1] is borrowed from Darwin's *Insectivorous Plants*, p. 4. "It is necessary, in the first place, to describe briefly the plant. It bears from two or three to five or six leaves, generally extended more or less horizontally, but sometimes standing vertically upwards. The shape and general appearance of the leaf is shown, as seen from above, in fig. 15. The leaves are commonly a little broader than long, but this was not the case in the one here figured. The whole upper surface is covered with gland-bearing filaments, or tentacles, as I shall call them, from their manner of acting. The glands were counted on thirty-one leaves, but many of these were of unusually large size, and the average number was 192; the largest number being 260, and the least 130. The glands are each surrounded by large drops of extremely viscid secretion, which, glittering in the sun, have given rise to the plant's poetical name of the sun-dew."

Page 9. "If a small organic or inorganic object be placed on the glands in the centre of a leaf, these transmit a motor impulse to the marginal tentacles. The nearer ones are first affected and slowly bend towards the centre, and then those farther off, until at last all become closely inflected over the object."

Secretion and motion. Page 16. "When an insect alights on the central disc it is instantly entangled by the viscid secretion, and the surrounding tentacles after a time begin to bend and ultimately clasp it on all sides." "If an insect adheres to only a few of the glands of the interior tentacles, these soon become inflected and carry their prey to the tentacles next succeeding them inwards; these then bend inwards, and so onwards, until the insect is ultimately carried by a curious sort of rolling movement to the centre of the leaf."

Double action and its results. *Remarks.* **Double Action**, two outcomes of action, often occur simultaneously in a living thing. In the potato plant growing under favourable circumstances double action

[1] See fig. 15, p. 210.

occurs, assimilation or manufacture of starch and storage in the tubers underground. In the germinating pea unequal bilateral growth leads to curvature and bending of the plumule downwards. A pulvinus is the motor organ at the base of certain leaves; if it be touched its cells swell on one side and movement of the leaf results, but no further structural changes occur.

Specimens showing that an impression may be produced on a living object, and its outcome may not be observable till a later period. Delayed expression.

160. Drosera rotundifolia. The tentacles are seen to move some hours after the fly has been caught.

161. Ficus repens. Young rootlets were made to press lightly on glass slips, they emit after about a week's interval minute drops of clear fluid which dries up and causes them to adhere to the glass. C. Darwin, *Climbers*, p. 186.

162. Maurandia Barclayana. Petioles, when lightly rubbed, move after a considerable interval of time, and subsequently become straight again. Darwin on *Climbers*, p. 67.

163. Gloriosa plantii. "When the hook has caught a thin twig, the point may be perceived in from 1 hour to 3 hours to have curled a little inwards; and under favourable circumstances, it curls round and permanently seizes an object in from 8 to 10 hours." Darwin, *Climbers*, p. 78.

164. Seedling. Movements of radicle occurred some hours after irritation, and subsequent amputation of the apex.

165. Drawings. *Linnæan Society's Transactions*, Feb. 1888. Effects of light in producing movements of protoplasm.

166. Transverse section of oak. Observe thick zone of wood which corresponds to growth of a warm year. We saw the foliage, and the crop of acorns, now we see the thickness of the wood of that year. We have to wait to see the outcome of the impression produced. *Delayed expression*

167. **A flower** fertilized by pollen from another flower of the same species.

168. **Fruit** of the same flower when the seeds are ripe.

169. **Plants** grown from seeds of last specimen.

Note. If pollen is applied to the stigma of a flower we subsequently observe development of the carpels and the ripening of the seeds. The effects of the cross-fertilization are not observed till plants grow from those seeds.

Specimens illustrating living things as being impressionable, and as the seats of Storage of Material or Force.

170. **A bean not germinated.** In the absence of moisture it is not impressionable to the effects of ordinary temperature and light.

171. **A bean that has been kept moist and germinated.** Its parts are now impressionable to light, touch, gravity, etc.

172. **A potato tuber spouted.** Its impressionability depends upon its buds (structure); its storage of material, and the intrinsic vitality of the buds.

173. **Oxalis leaves** show pulvini or motor organs, one at the base of each leaflet.

174. **Mimosa pudica.** The movements of the leaves of *Mimosa pudica* are well known.

Professor Balfour[1] gives a good description of the leaves of *Mimosa.* He says:

"The leaf of *Mimosa* is compound and bipinnate. The small pinnules or leaflets are expanded horizontally when the plant is in the light, and in its natural state; but when it is in darkness, as well as when its leaves are touched or irritated, the pinnules fold upwards, so as to bring their upper surfaces into contact, and at length the petiole is depressed, so that the entire leaf falls down. When light is introduced, or when the irritation is removed, the leaflets gradually unfold, and the leaf-stalk rises. If two of the

[1] *Class Book of Botany*, 3rd edition, p. 495.

leaflets at the extremity are touched, or are irritated by heat from a lens or by electricity, without agitating other parts, they fold upwards, and a similar movement takes place in the adjoining leaflets in regular succession from the apex to the base of the petiole. The irritation is also communicated to the neighbouring partial petiole, the leaflets of which fold in a reverse order, namely, from base to

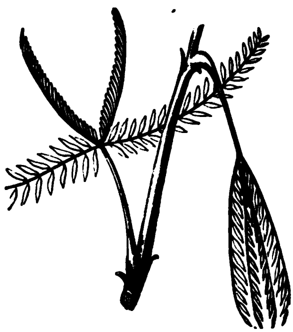

Fig. 14. Leaf of Mimosa pudica.

apex. The movements may be propagated until the partial petioles converge and fall down; and finally the general leaf-stalk is depressed. If the lower leaflets are first irritated, the foldings take place from the base to the apex of the petiole; if the middle leaflets are touched, then the foldings occur on each side."

175. A gourd moulded by pressure. When the fruit is growing rapidly its form is easily moulded by mechanical pressure.

176. A seedling cyclamen Seroicum. Tracing of downward apheliotropic movement of a flower-peduncle. Darwin's *Movements*, p. 434.

While circumnutating the plant is impressionable to action of light. That heliotropism is a modification of ordinary circumnutation is an inference drawn from the graphic records of the movements of stems, ordinary cir-

Spontaneity gives susceptibility.

cumnutation being replaced by the heliotropic movements, and reappearing when the lateral light diminished. The movement of a plant towards a lateral light is zigzag at first, later the line of its bending is almost straight, more rectilinear. It is probable that the lateral light does not arrest the circumnutation but changes the zigzag line of movement to a rectilinear one.

176 a. Kalmia flower. A good example of storage of force is seen in the Kalmia blossoms (*Kalmia latifolia*). The corolla closes in both the style and the stamens, which are seen just inside the corolla; the upper enlarged part of the stamen is its anther, or pollen-box, and this is lodged in a small pocket of the corolla. The stalk of the stamen, or filament, becomes bent as the corolla opens. The expansion of the corolla curves the filament outwards; this creates a mechanical tension in the filament. It is said that the "corolla opens;" this is a result of a certain mode of growth in the corolla which it is important to understand. While the corolla is in the bud state the inner surface of the corolla grows less quickly than the outside, and as a result the inner surface of the corolla remains concave, and the corolla closed. When growth is almost completed the inner surface of the corolla grows more quickly, with the result that what was the inner and concave surface now becomes convex and the flower opens, the style is exposed to the air, its stigma becomes the most prominent part of the flower, and the filaments of the stamens are placed under tension, their upper surfaces becoming convex; the anthers are still held mechanically in the pockets of the corolla. It may be seen that the cause of the tension in the filaments results from the movement of the parts of the corolla, and that this results from an alteration in the ratio of growth of the surfaces of the corolla. The tension in the filaments results from the ratios of growth in the surfaces of the corolla, and this is due to the inherited intrinsic forces in the plant. The anther, or pollen-box, discharges pollen through a small orifice at the apex of each cell.

Tension from curvature.

Curvature from unequal growth.

Tension from ratios of growth.

When an insect settles upon the flower it touches first the stigma, which is the highest part of the flower; the shaking which the flower thus receives liberates some of the stamens, and the anthers being liberated fly upwards and discharge their pollen on to the insect, which flies away with some of the pollen of this flower adhering to it. Now consider two such flowers and the bee which passes from one to the other collecting honey. The first open flower that he visits dusts his body with pollen; this he carries to the next flower visited, and there deposits some upon the stigma, at the same time receiving a fresh supply of pollen, which he carries off to the next flower. Thus cross-fertilization of the flower is effected. Whenever we come to observe movements of parts in plants the case is much more complex than with conditions of growth, the results much more striking and wonderful, and such examples are found in the most highly developed parts of the plant. Such examples are not spoken of as due to intelligence in the plant, but are very analogous in their outcome to acts that are termed signs of intelligence in animals.

Flower of Kalmia.

Enlarging field of observation.

Movement more admired than growth.

Remarks. It is convenient to place together groups of specimens which illustrate living objects as being impressionable and as storing up by their growth material or force. This is desirable because it may throw some light on those intrinsic conditions of living objects which give them aptness for action.

Examples of Storage of Force as the result of Growth.

Storage of force is seen in the growth of many fruits, and usually leads to the scattering of the seeds by mechanical means. In a species of wild geranium (*Geranium dissectum*), when the other parts of the flower have fallen, the central axis elongates in its growth; each seed is contained in a case, which is supported by a rod of tissue, which in the early condition of the flower forms part of the central axis, but gradually becomes detached from it.

When the seeds are ripe the case containing the seed becomes detached from the base of the supporting column and splits open, the rod is in a state of tension, and eventually becoming detached with a jerk, the seed is thrown some little distance. The cause of the tension in the rod is the unequal growth which occurs in its inner and outer surfaces; the inner surface, or that next to the central support, grows the most; tension or storage of force is thus produced, the mechanical energy is suddenly displayed when any jar is communicated to the plant, and scattering of the seed results. Examples of the storage of mechanical force might be multiplied. The lessons we may learn are that conditions of growth may produce mechanical action, which for a time may be stored up in latent form, and then become suddenly manifested in movement, producing a visible effect, which in its turn leads to important results to the species. Cross-fertilization is very important in producing good seeds. Scattering of the seed is essential to the spread of the species over the surface of the earth.

Examples of Storage of Material resulting from Growth.

176 b. A potato. Storage of material is effected underground in tubers, or thickened lateral branches of the stem.

General Remarks. The main points which have thus far been illustrated are:

(1) Modes of giving physical descriptions in place of general descriptions.

(2) Illustrations of attribute time as a character of acts of growth.

(3) Illustrations of attribute quantity as an intrinsic character of acts of growth.

(4) Control of the attributes of growth by physical forces.

PART II.

The study of series of acts of Growth.

Natural History and Psychology.

OBSERVATION of specimens may serve to train the mind to study the attributes of the processes of growth. The student may thus become accustomed to study the attributes of acts as seen in the action of nerve-centres producing the expression of mind. Some series of acts of growth may be seen to be followed by results so wonderful as to appear to exhibit the work of some intelligence.

The term "series" implies that the facts observed were not produced synchronously but in an observable successional order. The intrinsic characters of a series of acts depends upon the attributes of the successive combinations, and those of each factor in successive combination. In observing nerve-muscular acts we see visible movements, but we consider all the parts that at any time move during that series. In looking at a specimen as illustrating a series of acts of growth, it is convenient to consider all the parts at any time seen acting in the series. They may be thought of if not present in any particular act of the series, their appearance or disappearance at any portion of the series is a question of their time of acting only. Looking at a foliage twig with leaves fully developed we see the parts that assimilate, but not the outcome of the action; observing a series of nerve-muscular movements in man we see the outcome of action occurring in nerve-cells not the cells acting. A series of acts implies relation of successive acts as to time. We are speaking of series of visible acts, equivalent to series of visible movements. In viewing a specimen which is the result of growth we may see all the parts concerned in the series, or if some have been lost, they may have been previously observed and known. In considering a series of acts of growth we must enlarge the field of thought to include all members

Movement and growth.

of the series, then the parts acting in a particular combination is a relation in time; thus augmentation of parts acting in a combination, or diminution of parts depends upon the time of action of parts.

Specimens showing the importance of subdividing the object observed into the parts that may grow or act separately. Animal Specimens.

177. **A sponge** showing a colony of polyps.

178. **A piece of coral.**

179. A marine Hydrozoon.

180. **Amoeba.** Drawings showing fibres thrown out from its substance; those parts can act and move separately.

181. **Rotifera.** Drawings showing ciliated projections which can move separately.

182. **Frog.** Dissection shows parts of the animal concerned in producing movements. Brain, spinal cord, nerve-fibres and muscles. Various groups of muscles can contract separately.

Flowers and Inflorescence. Buds.

183. **Primrose flowers.** (*a*) long style; (*b*) short style.

It is necessary to look at the parts of each specimen to observe the different proportional growth in the essential organs of the two flowers. In the outer wholes of the flower proportional growth is similar in each case.

184. **Euphorbia.** An inflorescence, or colony of flowers.

185. **A sun-flower.** An inflorescence or collection of flowers which grow separately. It is a colony of florets collected on one support. The little flowers at the outer edge are of a different shape from those in the centre. A floret from the margin has a tubular corolla greatly prolonged on one side in strap-like form hanging over the margin of the flower head. The florets of the centre are

tubular and cup-shaped, and of equal height all round. There are points concerning the arrangement of the florets worthy of special notice; the florets in the circle at the margin open first and attract the visits of insects, the next day a circle nearer the centre opens, and so on in succession; thus fresh flowers open each day. We will now look at a single floret in detail, specially noticing the arrangement with regard to the relative growth of the stamens and the pistil, which results in cross-fertilization of the flowers. The stamens are united by the margins of their anthers, forming a tube into which the pollen is discharged. The stamens grow to their full height and maturity before the pistil, which during the early stage of the flower is short and immature. When the anthers are ripe and have filled their tube with pollen, the style begins to grow, and passes up the tube formed by the anthers pushing the pollen powder before it, which now accumulates in a heap at the top of the flower. Later, the continued growth of the style brings the stigma as the most prominent part of the flower, its lobes open and expose the receptive surface. An insect visiting the flower in its early condition meets with a heap of pollen dust at the top of each floret, and thus dusts its abdominal surface; when the insect later on visits a flower in the later stage of growth, with the style protruded and expanded, it deposits some pollen from the former flower upon the prominent and receptive stigma. Thus cross-fertilization is effected. The time of each act described is an essential attribute of the process which brings about cross-fertilization or conveyance of pollen from one flower to another.

186. Daisy flower. A composite; the flower here is called a capitulum. The florets are of two kinds, and form a colony. Observe that series of acts of growth are seen among the many parts of the flower. Proportional growth is seen in the parts of a single floret and results in cross-fertilization of the flowers.

187. Chestnut bud. It consists of many parts that grow separately.

Branches. Roots.

188. Sprig of may. The specimen shows many foliage buds or growing points. Separate action takes place in each bud independent of its neighbours, and must be observed separately.

189. Sprig of ivy. The specimen shows alternately leaves of last year's growth and a new shoot proceeding from the axil of each leaf.

190. Sprig of fir. The specimen shows the foliage of two former years and a terminal bud at which growth is proceeding.

191. Sprig of conifer. The specimen shows foliage of last year, and new shoots at many points.

192. Sprig of conifer, showing foliage growth of three different years.

193. Tuber of potato. The potato had been planted for a fortnight, and when taken up ten stems were found proceeding from the "eyes" or buds of the tuber. Each part of the tuber which has a bud can grow separately.

194. Crocus plant. The corm or thickened underground stem produces buds which may grow separately.

Note. The members of a plant are illustrated in specimens Nos. 132, 188, 228, 229.

195. Carrot plant. The stem has produced many separate leaves, but the root has no buds or separate growing points.

196. Turnip plant presents the same points for observation.

197. Radish plant shows only one growing point capable of producing a stem; there are no buds producing lateral members at regular points.

Physiological division of the object into parts that act separately.

198. Cell of Vaucheria which, though appearing homogeneous, is geotropic at one and apogeotropic at the other. *Sachs, 760.*

199. Brassica Seedling stem is apogeotropic. Primary root geotropic, and secondary roots are diageotropic. This is a physiological classification of parts, not an anatomical one.

200. Spirogyra, an alga. Drawings showing its free-swimming spores with cilia which act separately or in groups.

Uniform series of acts of Growth in two or more subjects.

Definition. In each successive combination of acts the same or similar units act in similar time and similar quantity.

Note. This form of series of acts concerns both time and quantity of action.

201. Equisetum. The foliage stem produces at each node a similar whole of similar foliage leaves.

Compare with non-uniform series where spore-bearing wholes appear.

202. Convolvulus. The stem produces a series of leaves till the flower-buds begin to appear, then the phyllomes which form parts of flower are modified.

208. Bur-plant. Stem showing successive regular wholes of leaves.

Note. Uniform series of growth appear less wonderful and like intelligent action than some of the non-uniform series.

Similar series of acts of Growth in two or more living things.

Definition. Series of acts of growth may be said to be similar when similar parts grow in the same relations of time and quantity.

Note. This form of series of acts concerns both time and quantity of action in two or more objects.

204. May foliage sprigs, 1887. Compared with similar sprigs 1888.

205. Foliage sprigs of the same tree, and same date.

206. Two daisy flowers fully open.

207. Two seedling plants from seeds of the same fruit.

208. Two kittens from the same litter.

209. Equisetum. Each internode with its whole of leaves may be considered a separate subject of growth. The series in growth is similar.

Series of acts of Growth uniform as to time, but are not uniform as to relations in the quantity of growth.

Note. This form of series of acts concerns quantity of action only, no notice is here taken of time as a character of the successive acts.

210. Sinapis alba. In the series of foliage growth we see parts produced in succession of various form, or proportional growth (relations in quantity), (*a*) Cotyledons, (*b*) ordinary foliage leaves.

211. Mimosa pudica. Observe that the series of growth brings into view in succession, (*a*) Cotyledons, (*b*) simple foliage, (*c*) compound foliage. All these parts differ in the ratios of their growth.

212. Passiflora coerulea. See Lubbock, fig. 94. The first leaves succeeding the cotyledons are entire, later leaves are palmate.

213. Cephalandra palmata. Seedling.

214. Larkspur flower. Calyx polysepalous and irregular, sepals are synchronous in development, but are not of equal proportional growth.

Series of acts of Growth non-uniform, successive members being added to the series, and continuing to grow, while older members live on but cease to grow. Reinforcement.

Reinforcement signifies the area of visible action expanding. More parts successively partaking in the action.

Note. This form of series of acts concerns the time of action only, no notice is here taken of the quantity as a character of the parts successively produced.

215. Sprig of fir showing old and new foliage belonging to successive years.

216. **An iris flower,** followed later by appearance of a second flower and a bee.

217. **A plant** contrasted with seedling which has less foliage, shows that the older one has been reinforced in its foliage, and consequently produces more assimilation.

218. **Transverse section of stem of chestnut** at 7 years contrasted with one at 21 years shows that older tree made more wood in each annual zone sequential to the reinforcement of its foliage.

219. **Epilobium** inflorescence. Successive flowers open and are added to the inflorescence.

220. **Growing point of equisetum.** Drawing, Sachs. Shows increase in number of cells without increase in bulk of tissue.

Series of acts of Growth, the number of parts lessening as growth proceeds. Suppression.

221. **Flower of poppy** fully expanded, compared with a flower bud; sepals are deciduous.

222. **Fruit of buttercup,** compared with a mature flower; as growth proceeds petals and stamens drop off.

223. **Capitulum of daisy.** The series of opening flowers is centripetal in direction, and the number of members in successive wholes diminishes.

224. **Horsechestnut flower.**

Note. In such inflorescences a series of successive wholes or combinations are developed, the successive wholes containing a diminishing number of flowers.

225. **Wallflower** presents serial development of two wholes of stamens; in first whole there are two stamens, and in the second whole there are four.

226. **Plane tree.** A sprig showing ripe fruit, and dead leaves, which are consequently inactive.

Series of acts of Growth. Successive members of the series not being similar in kind.

227. **Sprig of almond.** A series of blossoms develope,

then later a series of members which are different in kind from foliage leaves.

228. Foliage bud in development, scales, then leaves.

229. Flower bud, bract, sepals, petals, stamens, carpels.

230. Chestnut bud. A mixed bud producing a number of foliage leaves, then inflorescence.

Series of acts of Growth. Successive members of the series not similar in quantity.

231. Snow-ball plant, successive leaves not being similar in form or in proportional growth. The upper leaves are entire, the lower ones are indentated.

232. Seedling sycamore, cotyledons and common foliage differ in P. G.

233. Seedling mimosa cotyledons. Simple foliage. Compound foliage.

Compound series of acts of Growth. Compound action.

Definition. A compound series of acts of growth is one where the members acting change during the series so that at its conclusion the acting members are different from those at its commencement.

A compound series signifies a change in the individuals that act in the series. This depends on a relation in time of action of the members. Compound action may occur among the units of a living thing. The units of time in compound or other form of serial action may affect one another, or the serial action may be from the coordinating effect of a common force (law of Syntrophy). The final visible action may differ much from the early acts of the series. We observe the visible action, the intimate process is inferred.

In a compound series of acts the final action differs from the early acts of the series, and is "adapted" to or is thoroughly controlled by the circumstances.

234. Buttercup bud, flower and fruit on the same plant, (*a*) the four wholes are present, (*b*) the petals are lost, (*c*) stamens have fallen, (*d*) sepals have fallen, (*e*) ripe carpels alone remain. The fruit may be said to be well adapted to

its final purpose, the intermediate stages of growth were temporary.

235. Sprig of nut with male and female catkins. Male catkins fall off and the ripe ovaries alone form the fruit.

236. Root curved round a stone. Darwin, *Movements*, p. 198. When the tip of the root touched the stone, it was deflected from it. Then, under the influence of geotropism, it proceeded downwards till contact with the stone at a point a little above the apex was followed by the apex bending towards the stone till it came to the edge, when it bent directly downwards. Action of one set of cells after another produced the adapted movement.

237. A piece of peritoneum inflamed and covered with lymph (injected).

238. A piece of peritoneum forming an adhesion. After much action in many cells, action subsides and the final outcome may be useful.

A series of movements having a definite antecedent and sequence, is seen in the case of the tentacles of the leaf of *Drosera rotundifolia* when a fly has become attached to one of them.

A series of acts in Drosera leaf.

Mr C. Darwin, in his work on *Insectivorous Plants*, p. 4, describes the leaves of *Drosera rotundifolia* in detail. The whole upper surface of the leaf is covered with gland-bearing filaments, or tentacles. The glands are each surrounded by large drops of extremely viscid secretion, which, glittering in the sun, have given rise to the plant's poetical name of the sun-dew. The tentacles on the central part of the leaf are short and stand upright, and their pedicles are green. Towards the margin they become longer and more inclined outwards.

If a small organic object be placed on the glands in the centre of a leaf, these transmit motor impulse to the marginal tentacles. The nearer ones are first affected and slowly bend towards the centre, and then those further off, until at last all become closely inflected over the object. This takes place in from one hour to four or five or more hours.

When an insect alights on the central disc, it is instantly entangled by the viscid secretion, and the surrounding tentacles after a time begin to bend, and ultimately clasp it on all sides. If an insect adheres to only a few of the glands of the exterior tentacles, these soon become inflected and carry their prey to the tentacles next succeeding them

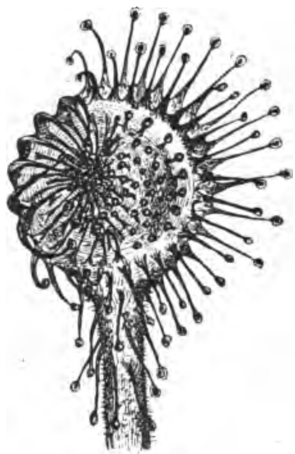

Fig. 15.—Drosera rotundifolia.
Leaf (enlarged) with the tentacles on one side inflected over a bit of meat placed on the disc. C. Darwin.

inwards; these bend inwards, and so onwards, until the insect is ultimately carried by a sort of rolling movement to the centre of the leaf. Then, after an interval, the tentacles on all sides become inflected, and bathe their prey with their secretion, in the same manner as if the insect had first alighted on the central disc.

Specimens showing that, among like objects, synchronous nutrition is often followed by subsequent synchronous action. (Syntrophy.)

239. Bunch of cherries, bearing many fruits in the same stage of development.

240. Carpel of pea, fruit ripe and opened, showing ripe pea seeds growing from the carpel, one ovule was not fertilized.

241. Lupin leaves in various stages of growth; the ratios of growth are similar in each at the various stages of growth.

242. A pot full of seedlings, all grown from similar seed. All have grown alike, and will continue to grow alike under similar circumstances.

Remarks. In all the above cases the objects proceed to grow equally, and are equally nourished, probably because supplied with similar food, and similarly and synchronously stimulated.

243. A swarm of bees. They are gregarious and work together; all have been stimulated by the same antecedents and circumstances.

Examples may be given where *the supply of pabulum to various objects has been similar but stimulation unequal.*

244. Leaves of a vine. Certain branches growing over a neighbouring flue produced all their leaves earlier than the other branches, and, under stimulation by heat, they grew larger than the leaves of other branches.

245. Gourd, leaves and fruit. A portion of one branch was carried into a dark box, the portion produced all its leaves equally small, but flowers and fruit were perfect. Goodall, Fig. 172.

Specimens illustrating movements in Plants, and the Mechanism by which their movements are effected.

A. Motion producing organs.

246. Mimosa pudica, fully developed compound leaf. Pulvinism is seen at the base of the main stalk at the base of each leaflet.

247. Oxalis, pulvini are seen at base of each leaflet.

248. Lotus Jacoboeus. Cotyledons with pulvini. Darwin, *Movements*, p. 116.

B. Specimens showing movement due to modes of growth.

249. Morning glory. A shoot showing method of twining due to unequal bilateral growth of stem. Goodall, Fig. 179.

C. Specimens showing means by which plants climb.

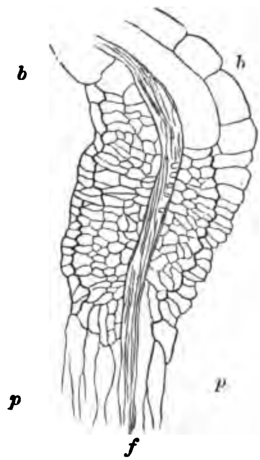

Fig. 16. After C. Darwin. Longitudinal section of a Pulvinus, magnified seventy-five times; *p*, *p* petiole of leaf stalk; *f*, fibro-vascular bundle; *b*, *b* commencement of blade of cotyledon.

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